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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 9 DECEMBER, 1918 WHOLE No. 155

A MORALITY CODE.[1]

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PART I.

For Children in the Adolescent Period.

In the proper training and development of the young mind there are certain fundamental principles which must be thoroughly understood by parent and teacher in order that the youth may receive the instruction in a manner that is practically unconscious to him, and yet in one that will cause him to grasp and appreciate them in such a way that they will become a part of his higher nature. It is the purpose of the writer to present in this code a series of fundamental principles to which an intelligent person can take no exception. These are suggestions which, if presented by a tactful parent or teacher and fully grasped by the child, will drive home truths in such a manner that the young person will absorb them with very little antagonism and will cause him to grow from youth into manhood developing that highest type of citizen, which will be of immeasurable worth both to home and country.

The child should be taught to realize that the parent and teacher are his best and truest friends, and that, that in which they instruct him is for his good and prepares him to meet life's activities.

The habit of cleanliness in all its phases should be urged upon the young mind, as many of the fundamental principles which he should understand are intimately associated with the prin-

[1]One of fifty-seven Codes written by as many persons selected from nearly every state in the Union from the ranks of those known to be successful in the government and education of large groups of boys and girls.
The author of this particular Code invites from everyone interested in the proper education and development of the American boy and girl, criticism and suggestions for its revision and improvement. He will thank the readers for a thorough and frank discussion of the merits or demerits of the paper.

ciple of cleanliness, not only of body but of thought and action as well. The degree of morality possessed by these young people is largely measured by their personal appearance, and though we may not go into detail, it is enough to suggest that they must have clean hands, clean nails, clean teeth, and other conditions which will commend themselves to the teacher and parent. These physical characteristics will inevitably lend a strong influence in producing within the young person's mind clean thoughts, from which will come clean speech.

Fundamentally the child should be brought to realize that there is within him a principle of honor which he himself must develop, not only to assure self-respect, but also to merit the respect of his associates. He must, in all of his dealings with his playmates, teachers, or parents, realize that honesty is paramount to any underhandedness that he might conceive would temporarily aid him in securing favor, position, or accumulation of wealth. He should also be made to understand that it is a function of his nature to assist his playmates, especially those who are weaker in mentality or in physical prowess, thus creating within him the spirit of lovableness to such a degree that it will become second nature to assist any who might be in need of help.

The adolescent child should be taught fairness in his play, whether in various recreations or in the game of his home and social life. He must play the game for its worth, and under no circumstances strive to win by any method of an underhanded nature. If in the family there are brothers and sisters, the spirit of filial love should be cultivated to its fullest extent, that they may be mutually helpful, not only within the family circle but in all undertakings where the interests of each or any are at stake.

Love and respect for parents should be of such a deep and abiding type that, whatever the situation, the child will adhere to their teachings. There are times in the life of the young boy and girl when they need a confidant. That confidant should be a parent, or ofttimes a teacher. This highly developed respect for parents and teachers will be one of the strongest faculties in holding the child to that way of living which develops the highest moral character. Honest respect for parents develops respect for neighbors, for the community, and for the property of others.

Respect by precept and example cannot be too early incor-

porated in the young mind. First, that for his elders should be so thorough and so complete that not only their instruction should be taken without question, but the experience and knowledge of those of superior environment and personality should be freely sought, that the younger generation may improve upon the unintentional mistakes of his predecessors.

The spirit of loyalty and honor to his school should be early created in the young mind, and should be of such a high nature that it will develop within him a desire to secure the best that that school can afford, and as advancement comes he will learn to observe and appreciate the many laws which necessarily exist to restrict and control such an institution but which would be of little value were not the young trained to naturally think and do right.

Courtesy and politeness are often innate and should be so early developed that no thought of disrespect to elders could enter his mind, and this principle should apply not only to those who are older but to his associates, every member of the household, and especially to the stranger and those in trouble.

Self-reliance should be a great asset, so that he may perfect the many faculties which lie latent in his nature.

The spirit of unselfishness if properly presented to the yearning young mind will develop and strengthen the attributes of true service, honesty, open-hearted preference, genuineness and other real virtues that go to form a strong and noble character. It may lead him to be active in civic betterment, in the enlargement of community privileges and in the upholding of the rights of the home, giving him an ideal of the best for his country.

Manliness in its generic sense must be taught early in life, that this particular quality of morality may lend its strong influence in assisting to develop the many other attributes which necessarily combine to make a true, well-rounded person.

Purity of language, whether at home, in school, or among associates, is an essential element to character-building. The abhorrence of the smutty, vile, coarse or indecent word should be instilled in the youthful mind, and especial emphasis laid upon the careless or thoughtless spoken word that so often mars the moral or cultured life of the user. The youth should be taught to finely discriminate between pure and impure words, coarse and refined expressions, passionate and impassionate thoughts, harsh and kind words, ugly and beautiful

terms, necessary and unnecessary criticism, and as he advances into the years of self-government, the proper use of synonyms, which form such a large part of the English language. He should also be impressed with the importance of correct speech, which makes the young person a great asset to any social or cultured community.

The results of negation must be presented to his mind as over against those obtained by activity in all those qualifications which go to produce the highest type of citizenship. The lessons drawn from examples of bad habits are invaluable when properly and tactfully presented. In this connection the evil influence of bad or immoral companions should also be so thoroughly impressed upon his mind that he will avoid such associates as he would any influence which would take his life.

Part II.

For Youths in Their Teens.

With reference to the youth of high school age, one of the most fundamental ideas of morality, and one upon which so many others depend, is the respect for property of others, whether private or public. If he can be taught to respect that which does not belong to him in the same way as he cares for his own, he will be a protector of public property, a conservator of matter and wealth, and a person who will abhor and use his influence against the tendency toward theft and graft when he becomes fully developed. Naturally will follow that patriotism which brings honor to his country and to whose principles and development he will be loyal and true.

He should be taught that any services that he may render in the home and in his own community, whether they be little or great, will not necessarily be fully compensated for in a cash stipend, but what is far greater, they will bring love and honor to the home, the school, or the community in which he lives.

A high type of morality can best be secured from a healthy and strong body; therefore, the necessity of caring for one's physical health should be an important and unneglected part of the daily routine work. If athletic, the youth should show such a keen fondness and proficiency for the sports engaged in that his play will be vigorous, on the square, and with the purpose that the best one will always win. Thus he can easily see for himself the wisdom of keeping himself absolutely unfettered from all kinds of evil and destructive vices which destroy mind and body. In being taught to disrespect vice in

all of its heinous ramifications he will understand that such indulgences lower his moral standard and hinder the development of a profitable and true citizen. Too much stress cannot be laid on the detrimental influence of bad habits, especially those which weaken the body or which, if exposed, cause reproach and shame.

He should be taught to be a worker and not a shirker, to work for what there is in his task and with the unison of faculties that will produce a high degree of efficiency.

Then should follow the virtue of being constructive, not destructive in his undertakings, bringing the ideas of morality into definite and complete operation, so that his labors can have no other result than that which will make his life worth while to live and his citizenship one to be honored.

A principle which some may depreciate, but which should be classed as a cardinal virtue, is promptness. He should always be in his proper place, on time, and ready for any work which he is asked to do.

The idea that any success in life will come through an active working mind can only be verified by the boy who, relying largely upon his own energies for the accomplishment of any task, has complete faith and trust in himself, and he will learn that to rely upon his own powers proves his own worth. He also discovers that to develop his various faculties he must so bring them into correlation with each other that he can command his whole being, instead of part of it, to accomplish his real purpose in life and to develop to a high degree his own worth.

He should be taught to avoid the foolishness of controversy and to apply the energies, which might here be wasted, to things of a constructive nature which will lead him to see the vital importance of seeking to increase his own productive powers in the vocation he wishes to pursue. Then naturally follows the importance of learning how to study oneself so as to discover the weaker points of one's nature, and how to strengthen and develop them into such attributes as will help one attain the highest type of manhood and womanhood. The will should be under complete control, but under no circumstances should any efforts be made to break or destroy the will of a youth, but influence should be brought to bear in such a way as to cause him to govern himself and thus develop the will to its very highest degree of individual action.

The social side of life has its demands. Sociability should

be presented as an essential or cardinal characteristic, and if the young person is diffident, methods of development must be used in a subconscious way so that eventually this condition, which strongly hinders advancement, will be removed.

The youth should become a good humanizer, that is, a mingler or a mixer with people, being taught that a gracious appearance and an affable disposition help to make a personality which attracts rather than repels.

The moral status of the schools with which he connects himself, while in the main depending on other influences, at the same time is largely dependent on the moral standard of the students. Therefore, any youth, being a part of that school and desiring to secure the greatest amount of cultural instruction, must carry to it a type of morality similar to that which he would wish to perfect in his own character. He should be impressed with the thought that he exerts an influence and that he alone can decide its type, whether detrimental or a source of moral strength to those with whom he comes in contact.

A phase of high morality should be developed in his education as far as knowledge of the business world is concerned. The youth in his upper teens should have an understanding of civic affairs, of making an ideal home, and of the nature and form of his government developed to such a degree that he will take an interest in and do that which will raise the standard of civic righteousness to an ideal of his own creation. He should work for humanity for humanity's sake. In whatever line of activity he may be engaged, he should be impressed with the fact that he must be temperate in all things, especially fighting the evil of overdoing.

The youth should be instructed in the principle that he is a part of the family, and therefore should become a family helper to assist in retaining or raising its moral standard. He should be made to feel that the family is a unit, each member thereof being a partner with explicit duties, thus creating the interest and enthusiasm necessary to make that particular family among those of the highest moral worth to that community. If his moral attributes have the proper trend, he might act as a family counselor, as he might bring to it information which possibly could be secured in no other way, and it would enable him through personal observation to better discriminate between right and wrong.

In all morality work he should be a helper and not a hinderer;

a true friend to all schemes for betterment of society; a student of not only civic but of physical and educational questions; a leader in character reform by studying and applying the suggestions given in this paper; and thus become a tower of strength to his companions.

The fact that big ideals should always be in front is supremely important in order that all phases of one's education may be so coupled together as to work toward the goal of a great ambition. Success depends very largely upon the possession of a clear, keen, active mind, which is the result of the development and embodiment of the various virtues herein mentioned. The brave heart is an attribute of a clear mind; therefore, with these two strong forces, the clear brain and the brave heart, the courage of one's convictions and the unhesitating realization of personal responsibility can carry to completion the most difficult tasks.

An attribute of great value here is that of determination to win. Success is what the youth wishes, and with firmness of character, correlation of faculties, and the spirit of determination incorporated within his mind, heart, and soul, he will win.

The youth should be taught to live, grow, and develop in a natural way largely through self-culture and discipline; to strengthen his own resources by becoming a reader of good literature; to be a lover of good biography; to become acquainted with those persons in history who have accomplished great things, to honor their successes and to profit by their mistakes. He should also be inculcated with the idea that under all circumstances he should be a gentleman of the highest type in order to meet his perfect ideal, and from whatever angle he may look, the virtues, attributes, and principles herein described, with their various viewpoints, should be within his horizon, to be incorporated into his life and to make him that type of citizen of which his family, his town, and his country will be proud.

ON THE HISTORY OF "PLAYFAIR'S PARALLEL-POSTULATE."

BY FLORIAN CAJORI,
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The cumbersome form of the parallel-postulate given in Euclid's *Elements* has been generally displaced in modern text-books by an equivalent postulate, often called "Playfair's Postulate": "Two straight lines which intersect one another cannot be both parallel to the same straight line." A different phrasing is the following: "Through a given point not more than one parallel can be drawn to a given straight line." Either form is much simpler than Euclid's statement: "If a straight line meet two straight lines so as to make the two interior angles on the same side of it taken together less than two right angles, these straight lines, being continually produced, shall at length meet on that side on which are the angles which are less than two right angles." Playfair himself laid no claim to the postulate as he gave it; in fact, he stated in the "Notes" to his edition of Euclid that it "has been assumed by others, particularly by Ludlam, in his very useful little tract entitled *Rudiments of Mathematics*," 1785. We presume that Playfair quoted Ludlam as the earliest claimant known to him.

In view of the popularity of this postulate, not only in elementary texts but also in advanced treatises on the foundations of geometry, it may be of interest to cite an author using it who antedates both Playfair and Ludlam. This author is Joseph Fenn, who published an edition of Euclid's *Elements* in 1769 at Dublin. This Euclid is part of the "*First Volume of the Instructions given in the Drawing School established by the Dublin-Society, persuant to their Resolution of the Fourth of February, 1768. . . . Under the Direction of* JOSEPH FENN, *heretofore Professor of Philosophy in the University of Nants, Dublin,* MDCCLXIX."[1] The usual sources of biographical and historical information fail to mention either him or his books. He argues in his edition of Euclid that the postulate given by Euclid "is not simple enough" and proceeds to remedy matters by interpolating between the 28th and 29th propositions of the first book a lemma that, if a straight line meeting two straight lines makes the alternate interior angles unequal, those two straight lines meet. In proving this lemma he makes use of a principle which in the body of the proof is designated as "C. N." (common notion): "A straight line which cuts one of two parallels will necessarily cut the other, provided this cutting

line is sufficiently produced." This is the same as the assumption of Ludlam and Playfair. This principle, says Fenn, "Euclid regards as self-evident"; Euclid makes use of it, Fenn says, in the 30th and 37th propositions of the first book, where a straight line cutting one of two or three parallel lines is made to cut all of them. As a matter of fact, Euclid rightfully regarded this property of parallel lines as constituting an immediate consequence of his own parallel-postulate.

[1]The frontispiece of this volume represents the Greek philosopher Aristippus (regarded as having been unfriendly to mathematical pursuits) as shipwrecked on the coast of the Rhodians. When he observes geometrical figures drawn upon the rocks, he cries to his companions in distress: "Let us be of good cheer, for I see traces of man," and thereby admits that mathematics stands for intelligence.

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ON THEORIES CONCERNING SOILS AS MEDIA FOR PLANT GROWTH.

By Chas. B. Lipman,

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(*Continued from November Issue.*)

These theories, together with the so-called laws of Liebig which I have just cited, were the cause of protracted controversies, some of which were not settled for a period of fifteen or twenty years. Indeed, one of the controversies (the nitrogen question) was not fully disposed of until 1885. The disputes in question were the result of experimental work in the field carried on by Lawes and later by Lawes and Gilbert in England, and beginning about the same time as the famous experiments of Boussignault in France. By actual results obtained on the analysis of the ash of certain plants and by the response of such plants to fertilizer ingredients, Lawes and Gilbert demonstrated that the composition of the ash of plants was no necessary index to the needs of plants for the mineral elements. They also showed that the air could not be depended upon to furnish sufficient nitrogen to plants when the soil was unequal to the task, reserving as incomprehensible the case of leguminous plants which usually proved to be exceptions to this rule. I wish that time and your patience permitted me to descant on the more detailed phases of those remarkable experiments of Lawes and Gilbert, wonderfully conceived, accurately planned, and scrupulously and ably executed, which served to answer and effectively dispose of Liebig's mineral theory and largely of his nitrogen theory; to tell of Liebig's patent fertilizer and the story and reason for its failure; and to describe the numerous investigations which these theories stimulated. It is impossible, however, to go into all these matters in the brief space of an hour. I must, therefore, content myself with what I have told you of Liebig's work and with the further comment that despite a number of errors which crept into Liebig's theories, the latter were essentially sound, and while they constituted very largely amplifications of de Saussure's theories and facts, they remain as great achievements from the point of view of scientific propaganda. The position in the annals of agricultural chemistry and in plant physiology occupied by Liebig, however, represents only a small part of the credit which is due him in the general field and particularly in the organic part of chemistry.

Before passing on to the progress of soil theory after 1860,

by which date the controversies between Lawes and Gilbert and Liebig were largely settled, there must be noted an old theory in regard to the cause of soil infertility, which has been of the greatest potency, directly or indirectly, in some of the most recent developments in soil theory. I refer to a modification of a very old idea of the selective powers of plant roots introduced into more or less modern literature by the distinguished French plant physiologist, Decandolle, in 1840. According to this theory, the roots of plants excrete certain substances which on accumulation become toxic to the same variety of plant, but not necessarily to other varieties of plants. Hence, the theory goes on to account for the benefits of crop rotation. It is interesting that this view should have been revived for the first time contemporaneously with the appearance of Liebig's report to the British Association, and particularly that it should have been regarded favorably by Liebig as the latter's more or less detailed consideration of it indicates. I shall return to a consideration of the Decandolle theory later in connection with a recrudescence of it in a period close to our own.

Great progress was being made in the sixties and seventies of the last century in all branches of science and much of it had its important relation to and effect upon soil theory. The brilliant work of Pasteur was going on and was opening the way for the development of modern microbiology, which dates from the discovery, by Robert Koch in 1882, of the plate method of isolating bacteria. Pfeffer and De Vries independently made their celebrated contributions to science in 1877 on the subject of osmotic pressure with particular reference to absorption by plants, thus rendering clearer the mechanism of salt action in the medium of plant growth. Many other pieces of outstanding work of a lesser magnitude were being accomplished. But none contributed anything to modify materially the theory of plant nutrition which may be regarded as a composite of the views of de Saussure, Liebig, and Lawes and Gilbert, on which all of those investigators would have agreed. Nor did any of them shed any light on the puzzling question of the legumes in connection with the nitrogen nutrition of plants. A radical departure from established experimental procedure was again needed as in several periods of the history of soil theory before. It was soon forthcoming, however, with the development of general, and closely on the heels therefore, of soil bacteriology. As far back as 1862, Pasteur suggested that nitrification was probably a bacte-

rial process. Up to then, and even for some time after that, it was regarded as a chemical reaction taking place without the inter vention of living organisms. In 1877, however, the year in which Pfeffer and De Vries made their important contributions to the subject of the osmotic character of the soil, Schloesing and Muntz, two French investigators, definitely demonstrated the process of nitrification to be of biological origin. They found that when sewage containing ammonia was poured very slowly through tubes of sand, the ammonia would come through unchanged for a period of twenty days, after which it would disappear partly or wholly and its place would be taken by nitrates. When chloroform was poured into the tubes, nitrates would soon cease to appear in the filtrate and again ammonia would be found. When the chloroform was allowed to evaporate and the sand reinfected with some fresh soil, nitrates would again be found in the filtrate in a few days. This demonstrated beyond a peradventure that nitrification was a process due to living agencies. It took thirteen years more, however, and the patient attention and sedulous industry of a number of leading chemists and physiologists, culminating in the isolation of the nitrifying bacteria by Winogradsky in 1890, to make clear the process by which nitrogen in soil organic matter is rendered into nitrates.

Even this splendid work on nitrification, including Winogradsky's classic contribution, however, would still have left unexplained the abnormal behavior of legumes in the experiments of Lawes and Gilbert. But the necessary explanation was made through the striking and epoch making discoveries of Hellriegel, and of Hellriegel and Wilfarth, made public in 1885, and soon confirmed by Lawes and Gilbert, and by many others. These investigators found that when planted in a sterile medium, legumes do not behave abnormally, but respond to soluble nitrogen like non-legumes, growth being more or less regularly increased with every increment of nitrate nitrogen. When, however, the medium was not sterile, they would at times behave like non-legumes and at times not. They found, further, that nodules containing large numbers of bacteria were always found on the roots of the plants behaving abnormally. They connected these various facts and decided that the bacteria in the nodules on the roots of legumes, by some mechanism, obtained access to the large store of nitrogen in the air, which was not available to non-legumes, or to non-infected legumes. The nodules had been known since 1687, and the bacterial bodies in them

had been known and described for a number of years before, but had not been directly and definitely connected with nitrogen fixation. Frank had suspected the connection and published his suspicions, but later retracted the idea. The organism of the legume nodules was isolated about 1888 by Beijerinck and named B. radicicola.

The puzzling questions and erroneous theories regarding both the transformation of soil nitrogen and the fixation of atmospheric nitrogen and their relations with the growth of legumes and non-legumes were thus finally cleared up and disposed of in the decade between 1880 and 1890. Other important contributions to our knowledge of the more intimate nature of soils, and the process of nitrogen transformation and fixation and of many other soil biological processes, have been made since 1885, but none of them has, in my opinion, affected fundamentally our theories on plant nutrition and on soil fertility; except that in general, as will be commonly agreed, the knowledge of the soil organisms which we have gained since 1882 constitutes an indispensable link in the chain of ineluctable evidence which indicates that the flora and perhaps the fauna of the soil are directly or indirectly essential factors in the transformation of all elements of plant food in the soil into usable forms.

For purposes of giving the proper perspective and necessary introduction to the next period in the development of our subject, it is well to pause for a moment and consider the circumstances which have contributed to it and made it possible. The history of soil theory may be divided by an arbitrary method, which I have adopted, into three periods. The first period covers the large era from ancient times to the beginning of the eighteenth century, which was characterized by much speculation, by little experimentation, and by scarcely any progress in the object of attaining unto a knowledge of how the plant feeds and grows. The second period may be said to begin about the year 1700 and to end about 200 years later. In the first half of this period, the experimental idea was rapidly developing and the aim of thinkers and investigators was to determine what the requirements for plant growth are. In the second part of this period, speculation was rapidly giving place to theory tested by carefully devised experiments, beginning with de Saussure and culminating in the researches by Liebig and his followers, Lawes and Gilbert, Hilgard, King, Grandeau and many others. It was in this part of the second period that the object sought from the

beginning was successfully attained. The requirements for plant growth were finally determined. The parts played by the air, by water, and by the soil in plant nutrition were made clear and accurately appraised. But it must be noted that the school of de Saussure-Liebig-Lawes and Gilbert was one in which fundamental knowledge only of the *requirements* for plant growth were sought and found. They taught us little or nothing regarding the soil as a medium of growth to the point to which such teaching could be employed in formulating an idea of the conditions which control the power of the soil to yield heavily or lightly. In other words, it appears that the investigators of the nineteenth century assumed that the most difficult problem in plant production was solved when we learned what the requirements for plant growth are and their sources. The application of these principles had not progressed far enough to indicate to all concerned that it was necessary to know much more about plants and their media of development—soils—before we could hope to control the yields of crops on a thoroughly scientific basis. The investigators of those days could not see that it mattered little *cacteris paribus* how much of certain essential elements to plant growth were present in the soil at one time in the life of the plant, if they were not there in sufficient quantity at another period of its existence. They assumed that the soil constituted a static system in which, in some simple manner, water, aided by acids from decomposing organic matter and from root transudations, dissolved the minerals of the soil and maintained them at a more or less constant concentration. They assumed that the addition of soluble fertilizer salts to soils meant entire solution of the former and hence availability in toto to plants. With all these assumptions and many others in mind, the subject of the more intimate nature of soil reactions was ignored, merely analytical chemistry was applied to soils to determine total amounts of materials present, fertilizers were applied by empirical procedures; and in general, the outstanding work of Way, of the developing school of physical chemistry, and of Van Bemmelen on colloids were not considered as of much direct importance to a study of the soil. In other words, soil study *per se* was neglected. But the last years of the nineteenth century began to hear an occasional voice of protest from some of the investigators who were thinking hard on the subject of the soul-wearying soil analyses in vogue and their almost entire meaninglessness, on the riotous empiricism of fertilizer practices,

and on the possibility of learning something more about the chemistry of the soil itself.

This was the status of the subject at the beginning of what I have classified as the third period in the history of soil theory and science, about the year 1900. The man to whom, in my opinion, we owe most for the inauguration of this new era is Cameron, whose work in turn was made possible through the fact of his connection with Whitney at the Bureau of Soils. Whitney's radical ideas on the functions of fertilizers, on the need for studying the soil's physical condition, and on the cause of soil infertility, made him rebel against the established order as early as 1892. He announced in that year that fertilizers function chiefly in improving the physical conditions of the soil and that the proper supply of water to plants by means of maintaining the proper physical conditions in the soil was the chief problem in crop production. Later on, he revived and amplified Decandolle's idea of toxic root excreta as being the chief cause of infertility in soils and the reason for the benefits of crop rotation by which means he believed fertility could be maintained. In these ideas Whitney was supported by Cameron, as above indicated, and by Schreiner and many other investigators at the Bureau of Soils. Cameron led the work on the physical and inorganic chemistry of soils, and Schreiner that on the organic chemistry of soils.

The longer Whitney and his associates studied the problem during the decade from 1893 to 1902, the more firmly convinced did they become of the validity of their theories. They appear to have regarded their theories subjectively, however, and made them the chief burden of the now celebrated Bulletin No. 22 of the Bureau of Soils by Whitney and Cameron, which was published in 1903. Since then, many papers have been published by the Bureau of Soils dealing with toxic root excreta and with studies on the physical chemistry of the soil or soil solution. The theory on the toxic root excreta has been made more inclusive and postulates also the presence in the soil of toxic organic substances produced in the decomposition of organic matter there. While nothing conclusive of practical significance has resulted from the search for such organic toxins, it has been demonstrated in those investigations, which are still going on, that toxic organic compounds are found in soils. Many such substances have been isolated from soil organic matter and much light has been shed on the organic chemistry of the soil, which,

until the investigations of Schreiner and his associates at the Bureau of Soils, had been scarcely changed from the crude ideas held by Detmer, Mulder and others from fifty to seventy-five years before. While, therefore, it still remains to be shown that crops on infertile soils are arrested in growth and depressed in yield by organic toxins, whether originating from root excreta or from the decomposition of soil organic matter by the soil flora, science owes a debt to Schreiner, Livingston, Whitney, and to many others working at the Bureau of Soils at one time or another, who have been directly or indirectly responsible for giving us a more intimate picture than we had ever had of the nature and complexity of the soil organic matter.

We must retrace our steps a little to return to the publications of Cameron, to whose ingenuity, clear and incisive thinking, and courage we owe, in my opinion, the development of our modern physico-chemical views of soils just as we owe largely to Schreiner the development of our modern ideas on the organic chemistry of the soil. As early as 1901, Cameron began the publication of papers which attempted to show the application of physico-chemical principles to soil reactions. He pointed out the fact that the soil is to be regarded as a physical-chemical system in which the various minerals and water form a solution of a certain composition and concentration when equilibrium is attained in the system. Since most minerals are only slightly soluble in water and since practically all soils contain the important rock and soil forming minerals, Cameron argued that when equilibrium is attained in any soil, other conditions being equal, the composition of its solution, as well as its concentration, must be very much the same as that in any other soil. He was so impressed with this idea that he proceeded to test it out by making a series of soil extracts with water after brief digestions of the soil with water. The differences which he obtained between the composition and concentration of different soil solutions were regarded by Cameron as being small and insignificant and he, therefore, concluded, as he stated in 1903 in Bulletin 22, in joint authorship with Whitney, that all soils contain extracts of the same general nature and concentration, the latter being great enough to supply everything needed for big crops; and that, therefore, infertility of soils was not caused by a lack of the mineral elements of plant food in soils; that fertilizers did not function to supply any deficiencies in that direction; that infertility in soils is caused by the accumulation of toxic organic compounds in soils; that

crop rotation would overcome the latter difficulty; and that fertilizers function to neutralize the effects of the root and soil toxins and to improve the physical condition of the soil. Cameron developed these and minor arguments in bulletins of the Bureau of Soils and in a series of papers published in the *Journal of Physical Chemistry*, and brought them together in what is, in my opinion, his epoch-making little volume entitled the "Soil Solution," which appeared in 1911. The basic principles in Cameron's theory consisted in first considering the soil-water system as a dynamic one in which constant movement and change of the components obtains, and second, that regardless of the total quantities of the chemical elements present in soil, it is the amounts of them in the soil solution, or in the water films investing the soil particles, which is the nutrient medium of the plant proper, which constitutes the important and significant factor in soil composition. Considered in the light of brief study and the comparatively meager development of physical chemistry a decade ago, the essentials of Cameron's ideas were theoretically correct, but like all soils investigators who have preceded him did, and like all who may follow him are likely to do, he overlooked some of the very points which his novel method of attack should have rendered clear to him. The more secure basis attained by physical chemistry since and the more deliberate thought on the whole subject with Cameron's views as a basis makes it appear today that the soil system is a dynamic one; that all soil problems must be considered in that light and not in the light of the static system which has been largely assumed for it heretofore; that soil minerals in all soils when attaining equilibrium with the soil water may yield solutions of approximately similar composition and concentration. But, and this was overlooked by Cameron, that the attainment of equilibrium in soils is not a rapid and facile phenomenon, if it is ever accomplished; that the large variations in the partial carbon dioxide pressures in different soil systems, and the great disparity which characterizes activities of microorganisms in various soils, for obvious reasons, vary the nature of the solvent to so large a degree that when the systems do attain equilibrium, their solutions may differ markedly in composition and concentration; that fertilizers do exercise important effects on the physical properties of soils, and may exercise antitoxic effects to the root excreta and soil toxins, but that their principal function is probably to affect directly by addition and indirectly by changing the solvent properties and reactive powers

of the soil solution, the latter's composition and concentration. Cameron, as a physical chemist, should have appreciated that fact, but didn't, probably partly because of the results of his analyses of soil extracts obtained by a rapid method of digestion, which precluded the possibility of attaining equilibrium in the system. He does not seem to have appreciated sufficiently, moreover, the importance of the small differences in concentration between the different soil extracts which he obtained nor of the effect of season, and hence of temperature and moisture, in accomplishing marked changes in the dynamic system of the soil. He did not realize, as we do now, that the power of different soils to supply anew nutrients which are removed from the soil by rapidly growing plants varies widely.

All of these points have been developed in the last six or eight years and still constitute vital subjects of investigation in their different bearings and relationships today. While, thus, physical chemistry, a better training of our investigators, and better facilities, have permitted us to make rapid progress in our views concerning soils as media for plant growth and to modify considerably many of Cameron's important teachings, the latter loom large in the annals of our science. They represent a fundamental contribution which necessitated a keen mind, clear thinking, unusual gifts as a chemist, and more than the usual modicum of courage to enable their proponent to escape from the moorings of conservatism, and facing alone the scientific world to break the shackles which had held in bondage the ideas of soils investigators for sixty years. In other words, it is Cameron's attitude rather than his experimental data which constitute his contribution. It does not detract from the credit which is due him to point out, as I have above, some of the serious errors into which he was led by his theories and his disputes. His position is, in my opinion, destined to be secure and eminent in the annals of scientific investigations.

The theories of Cameron and those of Whitney which have been directly or indirectly responsible for the investigations of the Bureau of Soils did not, as may well have been surmised, go unchallenged. It would be impossible in so short a time as is now at my disposal to review the record of the controversies which have raged between the Bureau of Soils on the one hand, and the soil chemists and agronomists of this and other countries on the other, during the last fifteen year period, and particularly during the first ten thereof. Such well-known soils investigators

as King, Hilgard, and Hopkins, and such organizations as the Association of Official Agricultural Chemists, have been aligned against Cameron and Whitney, and opposed to their theories. Due to the progress which I have just briefly sketched for you, which has been accomplished by soil chemists during the last six or eight years, the protests of conservative men and organizations have nearly all been silenced, however, and the general attitude adopted by Cameron with the modifications described, are accepted in this country today. Soil analysis by the strong acid digestion method and by the fusion method have been discontinued very largely and most chemists realize that it does little service to farming interests, and certainly to science, in the great majority of cases to determine how much of the elements essential to plant growth are to be found in soils. We have learned that we must devise methods for determining the composition and concentration of our soil solutions, must study the phase phenomena in such solutions, must learn what factors regulate all these in the field, and to supply the means by which they may be kept in optimum relations for plant growth. We owe much of our ultra-modern ideas on the soil solution, on methods for obtaining and studying it, and on soils in general, to a rapidly growing body of workers who are enabling us to shape Cameron's theories to the pattern of a vast body of new and striking facts. At the risk of making invidious distinctions by mentioning some and not others, I feel constrained to mention the outstanding work in the last five years of Bouyoucos, Morgan, Jordan, Burd, Hoagland and Stewart, Gillespie, Sharp and a few others who are applying with great success a few simple fundamental principles of physical chemistry to the study of soils. We owe a debt, further, to the plant physiologists who have been profiting, like the others, from the application of physical chemistry to their work. The results which they have obtained and which we are applying to good advantage in soils work are largely due to the outstanding investigations of Osterhout, Livingston, Dixon and Atkins, Stiles and Jorgensen, Brenchley, Shantz and of many others who are following in their footsteps.

From the combined results of modern plant physiologists and soil chemists, we are beginning to accord more importance to the role of the concentration of the soil solution as a medium of plant growth. In my opinion, a proper understanding of the effects of differences in concentration of the soil solution as affecting plants will probably go a great way toward solving some of the

most difficult problems in plant physiology with which we are confronted today. Particularly the problems involved in the so-called physiological diseases of plants would, it seems to me, be made easier by an understanding of the effect of the concentration of the nutrient medium on the diseased plants. For example, in such diseases as die-back and mottled leaf in citrus trees, it is not unlikely that we are dealing with concentrations of salts in the soil solution which are many times higher than those to which the roots of citrus trees are accustomed in their natural habitats, and hence derangement of the normal function of the leaves may result. This is particularly possible when, in addition to a high concentration of salts, a state of balance between the constituents of the solution obtains which is inimical to plants. This will serve as an illustration of the great possibilities which are in store for us in studies of the concentration and balance of the soil solution. The experimental data and observations which support such a theory cannot be reviewed here.

For the sake of completeness, another theory on the infertility of soils, which has been advanced in the last seven or eight years, should be mentioned. It is the one proposed by Bolley, to account for "flax-sick" and "grain-sick" soils. Bolley believes that such soils are rendered infertile through the accumulations, in large numbers, of parasitic fungi, introduced with poor seed, and self-propagating in the soil, which develop with the young plants and depress their growth. This theory has not received much serious attention, however, in spite of the fact that all agronomists and soil chemists seem to agree that the fungi in question may contribute to the depression in yields of those soils. With the fungi removed by the use of good seed, crop rotation, and tillage, the essential problem of maintaining the soil's power to produce still remains.

With the more intense study of the soil itself, which has characterized the last few years, there has gradually grown a more and more insistent demand for accurate methods in such study. One important basis for such demands should be referred to here, in view of its overwhelming significance for the future of all soil studies. I refer to the very marked variability which characterizes soil samples gathered in any field, no matter how apparently uniform, and no matter how close together the samples are taken. Only within the past several months, Frear has called attention to this great variability, and, independently and contemporaneously, one of my colleagues, Waynick, has

actually made a statistical study of one such case, the results of which not only are in agreement with Frear's view, but, in addition, lend mathematical precision to it. Moreover, it provides a basis by which such variability may be determined and a way is made open for the correct appraisal of the significance or insignificance of differences in the results obtained in experimental work.

I have given you in brief, and I fear only in fragmentary form, a survey of the important theories in the history of soils studies. Had I appreciated the true difficulty of the task of discussing them in so brief a space, I should probably not have undertaken it, since I realize how inadequately I have been able, for lack of time, to discuss some very interesting and important points which are involved. I trust that I have succeeded, however, in picturing to you the epochal monuments left by the great figures in the procession of thinkers and workers on soils, from the time of Virgil until today; to interpret for you the successive steps by which they have progressed; to appraise for you the relative importance of the contributions as I view them; and to give you a general idea of the status of our theories today. Above all, I desire to emphasize the fact that now, more than ever before, are we sadly wanting in the best kind of human material for our investigators in soils. The great triumphs of the past have indeed explained much, but, like all investigations, they have served to indicate much more that must yet be known and much that holds in store as great reputations and as many splendid victories as any of the phases of our problems which have been solved. But the problems which remain are of an intricacy and a difficulty probably surpassing anything which we have been obliged to face heretofore. We therefore need men who are second to none in imaginative capacity, in sheer mental vigor, and in training in physics, mathematics, and physical chemistry. To such, I can promise problems of an innate beauty, complexity, and fascination which are not surpassed in any other branch of science. I am optimist enough to believe that, though they have been slow in coming to us, we shall gradually impress such men with the importance of the work and enlist them in a service of the greatest interest to science, and hence of the greatest importance to mankind.

ATOMIC STRUCTURE.[1]

BY R. R. RAMSEY,
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Within the last twenty-five years there has been a radical change in our ideas of electricity and the structure of matter. The year 1896 is a memorable one in the history of physics. In the early months of 1896 Roentgen's discovery of the X-rays were heralded over the earth as a wonderful discovery enabling one to look through his pocketbook. In 1896 Henri Becquerel discovered the Becquerel rays. That is, that there is an invisible radiation given off from uranium that will darken a photographic plate, this discovery being the first in the science of radio-activity. In 1896 Zeeman discovered that when the source of light is placed in a magnetic field, the lines in the spectrum of the light are broadened and separated into two or more bands. This was an experimental verification of the electron theory of matter put forth by Lorentz a few years before, this theory being that atoms are made up of a number of electrons carrying negative charges of electricity rotating about a central body.

The word electron and a rough idea of an electron had been put forth in 1874 by Dr. Johnstone Stoney of Belfast. In 1879 Sir William Crooks had demonstrated his tubes and the fourth state of matter. Lorentz had given his theory a few years later. But it was not until after 1896 that the theory was looked upon as having much experimental foundation. Thus the electron theory of matter may be said to be based upon three fundamental experiments, X-rays, radioactivity and the Zeeman effect. From these and subsequent experiments we are forced to believe that electricity is made up of electronic charges. That a wire carrying a current becomes hot by the bumping, sliding or friction, if you wish to call it friction, of these electrons or carriers of negative charges which move in the opposite direction to that which the current is said to move.

Our idea of atomic structure is crude and has changed many times in the last twenty years. No doubt it will change many times in the future. Our model atom must explain all known phenomena, and must be changed or reconstructed to explain any new fact that is discovered experimentally.

We cannot hope to dissect an atom and analyze its various parts as we would a machine, an engine, say. We are groping in the dark. Suppose you never saw an engine, never had read

[1]Read before the Physics and Chemistry Section of the Indiana State Teachers Association, Indianapolis, November 1, 1917.

a description of one and you knew of no one who knew any more of engines than you did. And suppose you were set to the task of making a model of an engine. Suppose there was an engine running in a power house which was surrounded by a high tight board fence, the gates of which were securely locked. Before attempting to make your model engine you would go up to the fence and walk around the fence several times, paying close attention to every noise that could be heard. Then you would go to your workshop and make a model engine. Perhaps the only semblance to the real engine would be that you would have a model that would puff.

So it is with our atom model. We cannot discern and never can hope to be able to discern an individual atom by means of any of our five senses. It is only by means of indirect methods that we can see through a pocketbook. We detect radioactive substances by an indirect, electrical method, the electroscope.

Perhaps our model is at the puff stage. Perhaps it has passed that stage. Whatever the stage may be, we have arrived there after twenty years of listening and by twenty years of persistent hammering and prying at certain knots, trying to enlarge the holes so as to get a faint glimpse of the mechanism on the other side of the barrier.

There have been many models and theories of atomic structure proposed. Those that have survived are those that explain the various phenomena that have been observed. There has been a continuous patching, discarding, and reconstruction during the past two decades. The best model is the model that will explain all phenomena in the simplest manner.

Let us call attention to some of the things that must be explained, or look at that which an atom will do. At some of the things we have been able to see through our knot-hole.

1st. The elements combine with each other in definite proportion depending upon the atomic weight and valency. An atom of a certain element combines with one, two, sometimes more atoms of other elements but always in the same proportion with the particular element in question. This shows that matter is divided into definite chunks or atoms.

2d. The laws of electrolysis. A definite quantity of electricity carries a definite mass of metal from one plate to the other in a plating bath. Or, each element has a definite electro-chemical equivalent, depending upon the atomic weight and valency. We see that electricity and matter are connected in a definite manner.

3d. The periodic table. When the elements are arranged in a table according to their chemical properties beginning with the lightest, hydrogen, and the next heaviest, we find that they are arranged in a definite series through the various groups and recur again in series. Thus sodium and potassium, which are very much alike and fall in the same group, have seven elements between them when arranged according to weights. Each of these seven other elements belong, one each, to seven groups. These seven, together with the one to which sodium and potassium belong, make eight groups in which all the elements are placed.

4th. Light. All sources of light are matter of some form, solid, liquid, or gaseous. The spectrum of any light depends upon the source. The pitch of any tone depends upon the vibration frequency of the string, reed, or pipe from which it is produced. Thus a siren will tell you the number of vibrations per second which the fork or sounding body is making. In the same manner the D line in the spectrum of sodium will tell us the number of vibrations per second that the sodium atom or something in the atom is making.

5th. Zeeman effect. The Zeeman effect, where a line in the spectrum is doubled or tripled by subjecting the source of light to a magnetic field, as has been stated before, was the first experimental proof of Lorentz's theory of atomic structure. The fact that the double or triple lines in the Zeeman spectrum are circularly polarized shows that the source of light, something in the atom, is rotating and is retarded or accelerated by a magnetic field.

6th. Radioactivity. The science of radioactivity has advanced until today there is no doubt that radium is a disintegration product of uranium and that radium in turn is disintegrating and forming new elements. It is also known that during the time that an atom of radium is disintegrating it is throwing off bodies whose mass is comparable to the mass of atoms and is also throwing off bodies whose mass is one or two thousand times smaller than the atomic masses thrown off. It is known that the smaller bodies are negatively charged and that the larger bodies are positively charged, and that the numerical value of the charges are in the ratio of one to two, the positive charge being the larger. Our model atom must account for radioactivity.

7th. X-rays are due to cathode rays or electrons in motion

impinging upon a material target, a platinum anti-cathode, say. During the past five years the X-rays have been shown to be waves of very high frequency in the ether, or we may call them light waves whose wave length is thousands of times shorter than the wave length of ordinary light. Thus the atom when struck with a cathode ray must vibrate, or something in the atom must vibrate, with a frequency thousands of times greater than the frequency of light.

8th. Ionization. When X-rays or the radiation from radium passes through a gas it becomes conducting. The gas in the neighborhood of a red-hot wire becomes conducting. The gas in this conducting state is said to be ionized. We have an electron knocked off of a molecule of gas leaving the molecule positively charged and a free electron negatively charged. This electron may become attached to another molecule, making a negative molecule. This shows that an atom is made up of, or is surrounded with, electrons. A spherical pin-cushion full of pins might serve as an illustration.

9th. Photo electric effect. We have the photo-electric effect when a plate of zinc loses its charge when illuminated with ultra-violet light, or when the atom absorbs energy from the light.

10th. There are the various thermo-electric effects, Piezo-electric effects, and luminescent effects, all of which must be explained when we have our perfect model atom.

Various theories and models have been proposed. Probably the best and most simple is the Rutherford model, in which it is assumed that we have a central positive nucleus with one or more electrons rotating about it—a solar system, say, the sun the positive nucleus and the planets, electrons, rotating about it, the angular velocity of the electrons on the outside being less than those on the inside. In short, the planets or electrons obey Kepler's laws. This at once explains the Zeeman effect, assuming that the source of light is the electron moving in its orbit, the frequency of the vibration being the frequency of the electron in its orbit or at least is proportional to its frequency. A magnetic field will increase or decrease the radius of the orbit and thus change the frequency of rotation and consequently the position of the line in the spectrum.

The periodic series can be explained on this model if we make use of the Mayer experiment of the floating needles, which I had hoped to demonstrate here today. It is a long tedious task to attempt to explain the periodic series without the experiment

and I shall not attempt to do so. Suffice it to say that the needles will arrange themselves in certain geometrical figures which will recur in series as the needles are placed in the field.

The atomic weight of an element is proportional to the number of electrons rotating about the nucleus, although the mass of the atom is not due to the mass of the electrons, according to the latest idea of the atom. Thus since the mass of the electron is about one-thousandth of the mass of the hydrogen atom, we do not say, in the latest theories, that a hydrogen atom is a system of one thousand or more electrons. Indeed, Mosley, from certain work on the X-ray spectrum, concludes that the hydrogen atom is a positive nucleus with one electron rotating about it. The fact that the hydrogen spectrum has more than one line is due to the fact that one electron may rotate in different manners and periods at different times and in different atoms. Probably light is always accompanied or caused by ionization of the source; or, light is given off just before an electron is knocked out of an atom or just after the electron has returned to its positive nucleus.

When a swift moving electron, as in the cathode ray, strikes an atom of matter, we have a disturbance set up in our planetary system. This disturbance causes perturbations or vibratory motions of the electrons in their orbits which is the source of a wave disturbance known as the X-rays. The frequency of the vibration will depend upon the particular atom struck. Thus the characteristic X-rays from a platinum target is different from the X-rays from a rhodium target. The frequency is proportional to the atomic number (Mosley).

If by chance an electron were to be thrown off from our planetary system there would be a rearrangement or disturbance of the remaining electrons similar to that caused when an extra electron comes into the system and we have an explanation of gamma rays from radioactive substances caused by an explosion which throws off an electron or beta ray, gamma rays being the same as X-rays. If the atoms or molecules are violently agitated, as in the case of an atom in an incandescent gas or wire, we might expect that some atoms would bump together in such a way as to knock off some few electrons. We thus have an explanation of the ionization produced by flames and hot wires.

Certain electrons in certain atoms might be so situated or in such a condition that they could be disturbed by certain wave motions. This agitation could be so violent in the case of sym-

pathetic vibration that a few electrons would be thrown away from the atom and we have the photo-electric effect.

In a radioactive substance, uranium say, we will have to change our planetary system somewhat. We must still have a central positive nucleus or sun. Now let us call the electrons moons or planetoids. A number of these, 75 or 100, are revolving about the central sun. With these there are a number of planets, at least eight, in the case of uranium. The mass of these planets are four times the mass of the hydrogen atom, or the mass is the same as the mass of the helium atom. Each of these planets has at least two moons or electrons revolving about them. These systems or atoms are relatively unstable. At irregular periods we have an explosion and one of these heavier bodies is thrown off. We then have a new atom with different chemical properties and atomic weight. The body or alpha particle which is thrown off becomes an atom of helium, having a positive nucleus with two electrons rotating about it, the atomic weight being four. Thus our uranium atom, whose atomic weight is 238 and atomic number is 92, becomes an atom of uranium X after the atom of uranium has expelled an atom of helium. The atomic weight of uranium X is $238-4 = 234$.

After three of the heavier planets have been thrown off from our uranium system, we have an atom of radium which consists of the positive nucleus and 75 or 100 electrons rotating about the nucleus and at least five of the heavier planets. The atomic weight of radium is $238-(3\times4) = 226$. After the atom of radium has thrown off the five remaining helium atoms, we have radio-lead, whose atomic weight is $226-(5\times4) = 206$. The atomic weight of lead associated with uranium has been found by Richards to have an atomic weight less than the atomic weight of ordinary lead. The atom of lead is the positive nucleus with the 75 or 100 electrons revolving about it. As far as is known, it is stable and does not change. The lighter atoms differ from that of the lead atom only by the mass of the positive nucleus, the number of electrons, and the arrangement of the electrons about the nucleus.

Nothing has been said about the structure of the positive nucleus. No satisfactory theory has been put forth. It is known that the electrons are charged negatively, and in order to hold them in the planetary system there must be a central body, and it is assumed to be positively charged. Whether it is made of the same stuff as the electrons or of something entirely different

has not been determined. To me it is not unthinkable that it may be made up of electrons in some state of motion or configuration which renders the resultant effect of the bunch as if they were charged positively. As an illustration of what I mean, take two negative charges or bunches of electrons and they repel each other. Take two parallel wires with the current in the same direction and they attract each other. Stationary charges repel and moving charges attract each other. Why can not the nucleus be made up of electrons the configuration and the state of which causes them to act as if they were positively charged?

I have thus in a more or less vague way attempted to explain some of the leading phenomena known about the atom. The Mayer figures are a great help in forming a concrete idea of the structure of an atom. To those interested in atomic structure the time used in setting up and in study of the Mayer experiment and the extension which I have proposed will be time well spent. It is a visible illustration of what may take place in an atom. Whether this model based upon Rutherford's atom will explain all other physical and chemical facts can be determined only by the results to be obtained in the future.

COAL TAR DYES.

By Herman Wright.

Within the last forty years modern chemistry has furnished the dyer with many beautiful colors prepared from material extracted from the refuse tar produced by the distillation of bituminous coal in the manufacture of illuminating gas. These colors are generally produced in aqueous solution and precipitated therefrom in a powdered or crystalline state by the addition of sodium chloride, common salt. When filtered out, washed and dried, they are ready for market. The coal tar colors are usually soluble in water. They possess a natural affinity for animal fibres, and the shades produced upon silk and wool are particularly brilliant. The coal tar dyes, however, are not classified according to their tinctorial power or the shades which they produce.

History.

Down to the middle of the nineteenth century, natural dyestuffs alone, with but few exceptions, were at the command of the dyer. But as early as the year 1834 the German chemist

Range noticed that one of the products obtained by distilling coal tar, namely, aniline, gave a bright blue coloration under the influence of bleaching powder. No useful coloring matter, however, was obtained from this product, and it was reserved for the English chemist, Sir W. H. Perkins, to prepare the first aniline dye, namely, the purple coloring matter, mauve, in 1856. The discovery of other brilliant aniline dyestuffs followed in rapid succession, and the dyer was, in the course of a few years, furnished with magenta, aniline blue, Hoffman's violet, iodine green, Bismarck brown, aniline black, etc. Investigation has shown that the products of distillation of coal tar are very numerous, and some of them are found to be specially suitable for the preparation of coloring matter. Such, for example, are benzine, napthaline, and anthracene, from each of which distinct series of coloring matters are derived. In 1869 the German chemists, Goaebe and Libermann, succeeded in preparing alizarin, the coloring matter of the madder root, from the coal tar product anthracene, a discovery which is the greatest of all in historical interest since it is the first instance of the artificial production of a vegetable dyestuff. Another notable discovery is that of artificial indigo by Baeger in 1878. Since, 1856, indeed, an ever increasing number of chemists has been busily engaged in pursuing scientific investigation with the view of preparing new coloring matters of coal tar products, and of these, a few typical colors with the dates of their discovery may be mentioned: Cachon de Laval (1873); Eosin (1874); Alizarin Blue (1877); Xylidine Scarlet (1878); Biebrich Scarlet (1879); Congo Red (1884); Premuline Red (1887); Rhodamine (1887); Paranitraniline Red (1889); Alizarin Bordeaux (1890); Alizarin Green (1895). At the present time it may truly be said that the dyer is furnished with quite an embarrassing number of coal tar dyestuffs which are capable of producing every variety of co'or, possessing the most diverse properties. Many of the colors are fugitive but a considerable number are permanent and withstand various influences, so that the general result for some years has been the gradual displacement of the older natural dyestuffs by the newer coal tar colors.

As most of you know, the supply of dyestuffs has for the most part come from Germany for the last forty years. All users of dyestuffs know this and they also know that there have been various attempts made in this country to produce the coal tar dyes. At this time there is invested in the coal tar products

industry in Germany something like $400,000,000, probably more, employing some 50,000 people. Some of the factories pay dividends of 25 to 30 per cent after charging off a third of their profits to sinking funds for the erection of new plants and for other such purposes. This latter has been done for so long a period that most of the present property and plants do not appear on the books at all as assets, but have been built from the surplus profits. This is perhaps one reason why Germany has been so successful in the manufacture of dyestuffs. She has invested enormous sums of money, and as a result she manufactures these dyes on so large a scale that she can sell them at a very low price. Another reason for Germany's monopoly of the color-chemistry industry is the fact that there is a unity and solidarity of the various firms engaged in this industry, so that when one is menaced by any foreign competitor, they all act in unison. In America the field has been entered by many separated interests imperfectly acquainted with the complexity of the color problem, and a higher degree of unity is necessary in order to avoid overlapping and duplication of effort. Again, a reason why the United States has not been able to manufacture dyes is because Germans have discovered these dyes and have patented their manufacturing process, both in their own country and in the United States. The patents, however, are just now beginning to expire and the preeminence of German manufactured dyestuffs will soon be at an end.

The American people are just waking up to the fact that we are not doing for ourselves what we are able to do. It seems as though in the past there has been a tendency for the American people to let things of this nature be taken up and advanced by others. As long as the nations remained at peace with each other the United States succeeded in having their dyes produced in Germany without going to the trouble of manufacturing them themselves. Since the war, however, we have come to the realization that we must "help ourselves," as it were, and not depend upon other nations for the things which we can manufacture ourselves. One result of the war, according to an English authority, will be to put the United States on a footing of independence with regard to dye production, so that we will not only make all our own dyes, but export to foreign countries. The English writer in "Nature" (London, Dec. 16) warns his countrymen that when thus *forced* into new fields we may prove formidable competitors in the world's dye market. Before the war,

he tells his readers, American dye-factories employed not more than 400 workmen and produced annually 3,000 tons of dyes, prepared chiefly from intermediate coal tar products made in Germany. Since that time new plants have been built, and the output of American coal tar colors will soon be trebled, while the production of benzine and toluene has increased fivefold.

So you see according to this we have not been altogether idle and we can do a thing and do it well after it has started, but owing to the extreme manufacture of explosives it is difficult at present to secure large quantities of these hydrocarbons for color production. Nevertheless, twelve firms have embarked on the manufacture of aniline; the Edison Company is now turning out three tons of this intermediate product daily. A remarkable and novel development has arisen in this branch of color industry. The firms engaged in dyeing aniline black are setting up small aniline plants, costing $1,500 to $2,000 each, capable, under the supervision of one operator, of producing daily 100 pounds of aniline from benzine.

Now if these various firms owning the small plants, were to cooperate with each other and with any other companies which might develop later, the United States would be producing dyes on much the same principle as is Germany and, in time, on much the same scale. At present, however, the seven companies engaged on finished coal tar dyes are restricting drastically the number of colors produced and are concentrating on increased output. Although the existing equipment for natural dyes installed in six large American works has proved to be a *national* asset of great value, yet the total supply of dyes is still far short of customary requirements, and the American public is urged to meet the abnormal situation in a spirit of generous compromise. The existing shortage will soon disappear, inasmuch as the United States possesses all the enterprise, inventive talent, and technical ability requisite for the development of an American dye industry.

Perhaps some skeptical person will now come forward and inquire as to the use of these coal tar dyes. True, we dye clothes and most textile fabrics and we have come to regard dyestuffs and their colors as highly important factors in the production of fabrics, nevertheless, if we approach the subject from the utilitarian point of view, we find that dyestuffs do not add any real quality to the fabric; the color of the cloth may add much to its artistic appearance and give it beauty and charm that appeal to

our esthetic taste, but it cannot be said that color increases the durability, the strength, or the wearing qualities of the fabric. Outside of a certain influence upon heat and light rays, it is doubtful if color has any real influence upon the material value of the fabric. Our clothes would be of the same practical value to us if they were undyed as if they were dyed, they would wear just as well, in fact better, if they were never ornamented by the dyer's art.

Wherein, then, is the value of dyestuffs to the textile industry. To answer this: in the first place to satisfy man's natural love for ornamentation. Even the savage, wild as he is, decorates his scanty clothing with the varied, though limited, colors at his command. He is cultivating the love of beauty and any new color has a special attraction for him. It is this innate desire to decorate oneself and the things which one possesses and uses that has led to the widespread and almost universal application of dyestuffs in the manufacture of textile fabrics. In the second place, wholly aside from the artistic value is the desire to avoid, or rather to cover up, several undesirable features. When we wear our clothes for any length of time they become soiled. If the fabrics we use are white or undyed, their soiled condition is made apparent in a disagreeable manner. Consequently, we dye them in suitable colors, and though they still retain the same objectionable impurities, they are not so noticeable and we ignore them. Such of our clothing and other necessary articles, collars, undergarments, bed linen or table linen, towels, etc., as are left undyed are whitened thoroughly by bleaching, in order that when they become soiled they may present a disagreeable appearance and force us to take proper steps in cleansing them. Have you ever stopped to think why Italians prefer red bandana handkerchiefs, and why khaki colored shirts are so popular with camping parties? Think about it and you will find sufficient reason why dyes are important to the textile industry.

Now, why are coal tar dyes in more demand than the vegetable dyes which, it seems, are easier to produce? Or why have the synthetic dyes replaced the vegetable coloring matters? It is simply for the reason that the synthetic dyes could be produced cheaper and could be applied more simply and conveniently. Also, because more of the vegetable dyes were of an inferior quality as compared with the coal tar products. In the first place, the vegetable dyes were far from pure coloring matters. They consist principally of wood extracts and contained.

besides the coloring matters, many other extractive substances such as tannins, sugars, resins, etc. It was a very costly proceeding to isolate pure coloring matter from these complex vegetable extracts, in fact, in most cases it was commercially impossible. On this account, the colors given by most vegetable dyes were more or less impure and not clear in tone. In the second place, there are only a few of the vegetable dyes which may be classed as really fast colors in the modern sense of the term. Indigo was no doubt the fastest color, and still represents the standard for comparison. Logwood, which was once universally employed for the dyeing of black on all classes of fabrics, could be employed for the dyeing of colors fast to washing, but not especially fast to light and exposure to weather.

Now with the synthetic dyes, although some are not fast or substantial, the majority of colors used are far better than even the cochineal, which was considered one of the best of the natural dyes. These coal tar dyes can be produced in the pure state and are not marketable unless pure, so the color produced by them is always distinctive and clear of tone. This, besides the cheapness with which the dyes can be manufactured in comparison with the production of vegetable dyes, accounts for the preeminence of the synthetic coloring matters.

Now that the German monopoly of the coal tar dyes has been shown, our present lack of factories, caused by various different reasons, and the present situation in regard to the United States and synthetic dyes, I will try to picture to some extent what the future has in store for the chemist in regard to the manufacture of coal tar dyes. In the first place, it takes a man with a great deal of chemical knowledge to manufacture these dyes, and it therefore opens up a field for these highly educated men and gives them an opportunity to develop for the world a very useful industry, and for themselves a reputation that will be of long standing and uplifting. Outside of these facts, the development of the dye industry will offer employment to thousands of men and offer to thousands more the means of advancement and the means of obtaining riches. Why will it do this? Because the success of the whole textile industry depends upon the quality of dyes put in them. You need not be told how large the textile industry is, and when you consider how closely the two are connected and the present scarcity of dyes, you will see the future of coal tar dyes.

DOING OUR BIT IN THE TEACHING OF GEOMETRY.

By C. A. Hart,
Co-author Hart and Feltman's Geometry.

There never was a wider field for patriotic service than there is at present, and every earnest teacher who realizes the true meaning of the awful conflict in which we are now engaged, appreciating fully the issues which are at stake, must feel inspired to teach as he never taught before. For in conscientious teaching there is an almost infinite potentiality to counteract the propaganda which has been a menace to the solidarity of the United States, working its way insidiously into much of our school doctrine, promulgating a system which has for its goal a mechanical and soulless "efficiency" instead of the development of character in the search for truth, with the preservation and encouragement of individuality.

Nowhere perhaps is this breaking down of ideals more evident than in the mechanical teaching of mathematics which has gradually come into practice, especially in schools where pupils are trained to pass certain examinations. Everything which is not required by the examiners is rigorously cut out, and the dry bones of fact remaining are gone over and over and over again until the pupil is thoroughly acquainted with every turn of their limited surface.

In the good old days of the early Wentworth books the pupil was forced at least to experience such exercise of the imagination as was requisite for the solution of unclassified originals, but now the very perfection of parts of our best textbooks makes smooth the path for mechanical backsliding on the part of teachers who fail to realize the possibilities of mathematics, and particularly of geometry, as a study perhaps more powerful than any other for the awakening, strengthening, and developing of the highest faculties of the student. It is no wonder that otherwise progressive schoolmen are found who doubt the value of mathematics as a study; it is no wonder that other subjects are allowed to supplant it. When narrowly conceived and mechanically taught it has indeed no peculiar merit, for almost any subject can be so taught as to produce the same mechanical efficiency, if skillfully presented for such an end.

If, then, we are not keeping mathematics in the curriculum for its educational value, let us make short work of it. For mere practical use, a very few easy rules will suffice, and even these will be soon forgotten and unproductive of any good effects if not applied at once.

It is not the attainment of mere mechanical proficiency which should be the aim of the teacher who has the true education (and not merely the instruction) of his pupil at heart, although such proficiency should become a useful and necessary by-product. But his goal should be rather the development of that open and honest attitude of mind, of that capacity for the earnest and determined search after truth, irrespective of consequences, that have always characterized great mathematicians.

Such a goal is to be attained primarily not by insistence upon parrot-like limitation to a fixed routine involving cut and dried formulae alone, but by a patient and not too rapid cultivation of the imagination, so that its elasticity may enable it to spring to new discoveries; by the vigorous arousing of a passion for truth, so that glimpses offered by the imagination shall not be accepted until verified; by the strengthening and toughening of the faculties of reason, whereby the irresistible conclusions derived from patient investigation are finally accepted and established.

Let us consider the means by which such ideals may be attained in the teaching of plane geometry, and the difficulties which beset our path.

First in logical order are the definitions. In any subject the definitions should be clear, logical, and as simple as possible. The definitions in plane geometry are no exceptions to the rule. Indeed, no subject calls for greater exactness and skill, and although the student need not be required to learn many definitions given in geometry and he cannot be expected to formulate his own, yet it is essential that his fundamental concepts shall be as sure and as accurate as possible. Few textbooks are satisfactory in this respect; for instance, take the definition (?), "A straight line is the shortest line joining two points." What is meant by shortest line? A straight line can be compared with another straight line, but the length of a straight line cannot be compared with that of a curve or that of a broken line or any other kind of line. Such a definition leads to a wrong attitude of mind, which once attained will be difficult to change later.

Again, a popular definition of an angle is "the amount of opening," etc. How can the vertex and sides of an angle be considered parts of it, if the angle is "the amount of opening," etc.?

It is suggested in some textbooks that if a circle is divided into 360 equal parts and the ends of one of these parts joined to the center by straight lines, the angle formed at the center is one de-

gree. Yet, after accepting this statement for months, the pupil is then confronted with the theorem: "If two arcs are equal they subtend equal angles at the center." How confusing to any thoughtful student! How destructive of faith in the logical development of the subject! How hopelessly muddling to the ordinary mind!

Certainly a teacher must seem at least erratic if he considers the definition of a degree convincing and not requiring proof, and yet later insists upon a proof of the theorem quoted above. What idea is supposed to be conveyed by the definition of a degree, if we are to be uncertain (until the later theorem) whether all degrees are equal.

It is evident that there is little logic in such a sequence as that referred to above. A needless confusion is the natural result, and the only reason that a teacher may not protest against it is that he forgets how absurd such a procedùre seemed to him when first presented to him, or else he never thought about it at all.

We are told that a semicircle is an arc equal to half a circle. A semicircle is not then a segment. Yet in the corollaries following the inscribed angle theorem, angles inscribed in semicircles and angles inscribed in segments are compared and it is implied that a semicircle is a segment.

A definition of a figure should be such that it is possible to draw it by following the definition as a direction. For example, if we say that a rhombus is a rhomboid having two adjacent angles equal, we may proceed thus:

Draw any line, as AX. Draw AY making any convenient oblique angle with AX. Lay off a convenient segment on AX as AD and lay off AB on AY = AD. Through B and D draw parallels to AX and AY respectively. Let these lines meet at C. Then ABCD is the required rhombus.

1. ABCD is a parallelogram. Its opposite sides are parallel by construction.
2. ABCD is a rhomboid. It is a parallelogram having an oblique angle by construction.
3. ABCD is a rhombus. It is a rhomboid having two adjacent sides equal by construction.

Many texts, however, give the following: "A rhombus is a rhomboid whose sides are equal." Now if we try to draw this figure according to directions we shall be confronted by requirements that are impossible to fulfill by construction. First we must construct a parallelogram having all its angles oblique. Having chosen the first oblique angle, is the next to be taken at random? How can we construct a quadrilateral having four oblique angles? We can construct three oblique angles in draw-

ing our quadrilateral, but the fourth is determined by the three already constructed. The student has no means of knowing (without proof) that the fourth angle will turn out to be oblique in spite of his volition pro or con.

Even if all four oblique angles could be constructed, as implied by the definition, the pupil is now confronted by the necessity of making the figure a parallelogram, i. e., he must somehow secure opposite parallel sides.

Let the student begin over again, this time constructing the opposite sides parallel. Then he must prove that the angles are all oblique. Now grant that in some providential manner a rhomboid has been secured. It remains to get all the sides of this rhomboid equal. How is this to be done without beginning all over again? And how could he possibly draw the last line of the figure so as to make it equal the other three?

Some may think that this criticism is over exact, that the figure under consideration may safely be assumed as possible to construct, and that the student will see no difficulty in this connection.

But it must be admitted that the definitions of parallelograms must precede the theorems concerning them. How inconsistent it is then to assume a knowledge of the relations of the parts of the figures and afterwards prove that these relations exist.

The fact that the student may not discover the looseness and inconsistency of the definition is precisely the reason why the utmost care must be used. If he could discover the flaws in a poor textbook, it would matter very little what text should fall into his hands. Unfortunately, even teachers often fail to give clear and concise expression to their ideas, clinging with absurd tenacity to definitions to which they are accustomed, supposing that certain statements must be full of light for the students because they have become ground in, as it were, to the subconsciousness of the teacher.

For the sake of argument, however, let us grant that we have been too critical, and that such fineness of thought goes over the heads of the young. Of the two definitions given above, which is the simpler? Which is the easier to construct? Which is easier (after construction) to prove as fulfilling the requirements of the definition? In the later construction work it is of great value to be able to prove clearly and logically the correctness of a construction and, as in the case cited, to be able to proceed in a scientific manner from general to particular properties, showing first

that the figure is a parallelogram; secondly, that it is a rhomboid; and thirdly, that it is a rhombus; giving evidence at every step of a clear concept of the properties of the quadrilaterals named, and the ability to classify them.

I have touched upon only a few of the definitions in common use. There are many others equally deplorable which are widely used but betray themselves to him who thinks.

Not only should definitions be given with great care, but the theory following should be consistent with the definition adopted. For example, suppose we agree that "a unit of surface is a square whose side is a unit of length" and that "the area of a surface is the number of units of surface which a given surface contains." Some authors even guard against misunderstanding by adding that area implies a number and not a vague largeness. It is a very common inconsistency a little later to attempt to prove that "Two rectangles having equal altitudes are to each other as their bases" in the following manner:

Call the two rectangles R and S, respectively. Assuming the bases commensurable, a common unit of measure is laid off upon them in turn, perpendiculars are erected at the points of division forming rectangles. Suppose there are r rectangles in rectangle R, and s rectangles in rectangle S. We are then told that

$$\frac{\text{area R}}{\text{area S}} = \frac{r}{s}.$$

Now from the definitions preceding this proof we are led to understand that area R means the number of square units in R, and area S means the number of square units in S. What then does R/S mean? And why does it equal r/s? If R/S does not mean the ratio of the measure numbers of the two rectangles what then does it mean? We must use every precaution against vagueness in the notion of size. How can we apply our definition of area to the case in point? In the next theorem, as usually given, "Any two rectangles are to each other as the product of their bases and their altitudes," the meaning of R/S becomes still more obscure. Is area R a number of unit squares? In area S, is the same unit square assumed? Are we to understand that four lines, the two bases and the two altitudes, all have a common unit of measure? Since the two rectangles are any two, must we expect R/S to be a rational fraction? If we are supposed to know that "any two rectangles" means two rectangles whose bases have a common measure and that this

measure is also a measure of each altitude, then would it not be simpler to lay off the measures and find the real number of unit squares in each rectangle? Remember that all this confusion of ideas has been met without even attempting the proof for the incommensurable case.

Last of all, a third theorem appears telling us how to get the mysterious area of a rectangle (any rectangle?) which was certainly presupposed in the two preceding theorems. The proof of the third theorem is based upon the first two, which assumed the measure numbers (areas) of the rectangles involved. A vicious circle indeed!

Even the dullest pupil balks at the third theorem, having swallowed the other two, and perhaps having rather gloated over the cancellation of that unnecessary auxiliary third rectangle!

Another definition which leads to inconsistencies is that of a circumference. Some say that the circumference is the length of the circle. Yet they said previously that the circle was a curve, and later they discuss the area of a circle, i. e., the area of a line. Now what is the length of a curve? How can a curve be measured? How can a curve be a multiple of a straight line? Yet the pupil is told that the circumference is about 3 1/7 times the diameter (or π times the diameter) and the diameter is a straight line.

Again some proofs give the pupil the impression that the perimeter of some inscribed polygon will become the circumference of the circle if the number of sides is repeatedly doubled.

It is a confused impression, and no explicit statement is given as to how to go about measuring a curve. The pupil has no idea where π comes from. It is unrelated to anything that he has proved.

Now the fundamental principles connected with length of circumference (and also with area of circle) are both simple and fascinating.

One can easily show that the perimeter of a square circumscribed about a circle is 4, referred to the diameter as a unit, and that the perimeter of the inscribed square is 2.828427.

By drawing circumscribed and inscribed octagons, polygons of sixteen sides, etc., the pupil can easily prove that the perimeter of the circumscribed polygon decreases while that of the inscribed polygon increases. If we wish to make the work as simple as possible, we can give the following table without computation or proof.

No. of sides.	Perimeter of inscribed polygon in terms of diameter.	Perimeter of circumscribed in terms of diameter.
4	2.828427	4.000000
8	3.061467	3.313708
16	3.121445	3.182597
32	3.136548	3.151724
64	3.140331	3.144118
128	3.141277	3.142223

and so on up to the polygons of 4096 sides whose perimeters agree to five decimal places, each being 3.14159+.

The pupil watches with great interest the growing agreement of the figures and he is quite ready to accept the definition: The length of a circumference is the common limit which the successive perimeters of inscribed and circumscribed regular polygons approach as the number of sides is successively increased and each side approaches zero as a limit.

It is a great satisfaction to the pupil to see that if he uses 3.1415 he is using an exact value, correct to four places of decimals, that it has a real definite meaning, that by continuing the table we may obtain values correct to as many places of decimals as we please.

Above all things we must strive to give the pupil correct fundamental principles. We must set his face toward the goal of truth. We must develop in him courage rather than vanity, patience rather than conceit.

There is plenty of easy work for encouragement. It is well in addition to this to have a true measure of one's capacity and also of one's attainment.

FULLER'S EARTH IN 1917.

The production of fuller's earth in 1917, as shown by a report published by the United States Geological Survey, Department of the Interior, was 72,870 short tons, valued at the mine at \$776,632 or \$10.66 a ton. The increase over 1916 was 5,048 tons, or 7 per cent, and \$69,681, or nearly 10 per cent. Since its beginning, in 1895, this industry has almost steadily increased until, in 1917, its output and the value and average price per ton of its product were the highest yet attained. The output in 1917 was nearly eleven times greater than in 1895, and the value was nearly nineteen times greater.

Fuller's earth is found in many states, but in 1917 it was mined and marketed in only six. Florida was the leading producer in 1917, having been credited with more than three-fourths of the total output and value. The other states, named in order of production, were Georgia, Texas, Massachusetts, Arkansas, and California. The Southern States produced 98 per cent of the domestic fuller's earth marketed in 1917. The imports of fuller's earth, 16,994 short tons, also increased in 1917, but they formed only 19 per cent of the consumption.

MAKING ALGEBRA FEED THE ALLIES.

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While opinions of teachers may differ widely on the proposition of bread and butter as a chief end in school mathematics, especially high school mathematics, it is comparatively easy to agree when we have set before us a definite project of undoubted educational value that also carries with it a liberal serving of bread and butter on the side. Hence, I do not anticipate much opposition to the idea that if students of first year algebra can be taught to help relatives and neighbors to feed their stock and fertilize their gardens more economically through the help of the students' regular classroom exercises, there is certainly every reason for promoting this kind of mathematics drill in preference to traditional book material that presumably benefits nobody but the student himself.

Mixing problems in feeds and fertilizers furnish an abundance of drill in simultaneous equations, graphed or otherwise. The results have a real value for anybody who keeps an animal or plants a plot of ground. Although mere calculations, of course, cannot take the place of a certain amount of knowledge as to what kinds of feeds agree best with each kind of stock, what fertilizers, for instance, leach through open soils and are wasted, which improve the texture of such soils, etc., these calculations are of decided value in testing the ingredients used in any particular case, and in suggesting variations of proportions, where needed, to secure greater economy of production. Our proposal is to have the class learn to solve problems like those given here, and at the same time collect local problems from the neighbors for class, group, or individual solution, and return answers in which somebody is vitally interested. In other words, we propose that algebra be made to help feed the allies and ourselves, and incidentally, perhaps, to help justify a subject that, for the most part, has had too little justification, except that of a hypothetical mental discipline. In passing let us say that this is but one of a hundred ways in which algebraic calculation can be motivated for the average individual, even the boy and the girl, when practical needs and not academic traditions are made supreme in the teacher's and textbook maker's art.

Balanced Rations.

One of the great secrets of economy in feeding animals is to

balance their rations, so that all the food elements, nitrogen (protein), carbohydrates (starch-sugar), and fats, are furnished in the right proportion. Otherwise stock will be starved for the least abundant ingredients, or else fed more of the others than nature requires, with consequent loss of valuable material and strain on the animal's system in throwing off waste.

To illustrate: A pig needs 27 lb. of skim milk alone to produce a pound of growth. It needs 5 lb. of grain alone to produce a pound of growth. But mix the two, and 5 lb. of grain and only 15 lbs. of milk will produce the 2 lb. of growth, a clear saving of nearly half the milk.

Nutritive Ratio.

Pure fat is 2 1/4 times as nourishing as pure carbohydrate. Either one, for the most part, can be substituted for the other in that ratio. Many tables, for this reason, multiply the amount of fat by 2 1/4, and combine with carbohydrates to simplify figures.

The ratio of protein to the remaining nutrients, thus combined, is called the nutritive ratio. Below are tables of nutritive ratios of common feeds, and the nutritive ratios needed by the various kinds of stock. From them it is possible to calculate the proportion in which the various feeds will need to be combined. The results, based on nutritive ratios, refer to the proportions of nutrients actually digestible, not to gross weight of foodstuffs, which will depend upon the percentage of the foodstuff actually digestible, and can afterward be found by a separate calculation. Mere calculations, of course, are not the only things that have to be considered in feeding. Practically, the stock raiser has to consider palatability, bulk, laxative effect and price as well as proportion of mixtures. Individual animals, as well as individual people, vary somewhat in their requirements. All this, however, does not destroy the value of these calculations for anybody who has stock to feed, and wishes to do it in the most productive manner.

Illustrative Problem.

What proportions of skim milk and corn are best for a 5 mos. pig of 100 lb. weight, if one has plenty of both?

Skim milk: 8.8% digestible; nutritive ratio............1 : 2
Corn, 84.3% digestible; nutritive ratio............1 : 9.7
Pig requires 3 lbs. digestible; nutritive ratio............1 : 5

1. To find the proportion of digestible nutrients in each:
   Let x = number of parts of digestible nutrients in milk.
   y = number of parts of digestible nutrients in corn.
   $x/3$ = number of parts of protein in milk;

$2x/3$ = number of parts of non-protein in milk;
$y/10.7$ = number of parts of protein in corn;
$9.7y/10.7$ = number of parts of non-protein in corn.

2. To find the gross weights of these feeds required:
Total number of parts of digestible nutrients required: 462;
Total number of lb. of digestible nutrients required: 3.
Each part, therefore = 3/462 lb. Milk = $141 \times 3/462$ = 423/462 lb. digestible. Dividing by .088 = 10.4 (approx.) lb. milk, (ans.)
Corn = $321 \times 3/462$ = 962/462 lb. digestible. Dividing by .843 = 2.5 lb. (approx.) corn (ans.).

In practical work, rations are seldom so simple as this. In feeding cattle, sheep, and horses, it is necessary to feed a certain amount of roughage (hay, fodder, silage, rootcrops) and several different kinds of concentrates (grain, seed cakes, molasses, etc.). In constructing the ration, find how much roughage the animals will clean up. Compute the amount of digestible protein and non-protein in the roughage; subtract from the total requirements of the animal and then work out the proportions of the remaining feeds, by simultaneous equations, so that the whole will balance properly. Where more than two concentrates are used, the proportions of some of them, particularly those of similar nutritive ratio, will have to be set arbitrarily and averaged together in the equation.

Illustrative Problem.

A 9 months calf weighing 500 lb. receives 9 lb. corn silage a day. How much shelled corn and cottonseed meal are needed to make a balanced ration?

Growing cattle require 1.74 lb. digestible nutrient per cwt.
Nutritive ratio for cattle 6-12 mos., 1 : 6.
Corn silage is 13.8% or .138 digestible; nutritive ratio 1 : 14.3.
Corn (grain) is 84.3% or .843 digestible; nutritive ratio 1 : 9.7.
Cottonseed meal is 81.6% or .816 digestible; nutritive ratio 1 : 1.2.

Solution of roughage.
9 lb. silage $\times$ .138 digestible = 1.242 lb. digestible.
1 part protein in silage + 14.3 non-protein = 15.3 parts in all
1.242/15.3 = .081 lb. protein in silage.
1.242 − .081 = 1.161 lb. non-protein in silage.

Solution of remainder of the ration.
1.74 lb. per cwt. $\times$ 5 cwt. (wt. of calf) = 8.70 lb. nutr. required
1 part protein + 6 non-protein = 7 parts in all
8.70 lb./7 = 1.24 lb. protein calf requires
8.70 lb. − 1.24 = 7.46 lb. non-protein calf requires
1.24 lb. prot. calf requires − .081 lb. in silage = 1.159 more req.
7.46 lb. non-prot. calf requires − 1.161 lb. in silage = 6.299 more req.

Let x = number of pounds of corn needed
y = number of pounds of cottonseed meal needed.
$.843x$ = no. lb. digestible of corn.
$.816y$ = no. lb. digestible of cottonseed meal
$.843x/10.7$ = no. lb. protein in corn
$.816y/2.2$ = no. lb. protein in cottonseed meal
$9.7(.843x/10.7)$ = no. lb. non-protein in corn
$1.2(.816y/2.2)$ = no. lb. non-protein in cottonseed meal

Equation:

$$.843x/10.7 + .816y/2.2 = 1.159 \text{ lb. protein}$$

$9.7(.843x/10.7) + 1.2(.816y/2.2) = 6.299$ lb. non-protein
Solving,
$x = 7.3$ (approx.) lb. corn,
$y = 1.57$ (approx.) lb. cottonseed meal.

PRACTICE PROBLEMS IN RATIONING.

1. Make a table showing the amounts of each of the following combinations for the following ages of pigs:

Age (mos.)	Weight	Corn and Linseed Meal		Corn and Wheat Middlings		Corn	Skim milk
2 to 3	50 lb.						
3 to 5	100 lb.						
5 to 6	125 lb.						
6 to 8	170 lb.						

2. If 1/2 the feed of a heavily worked farm horse of 1500 lb. is balanced (clover hay and oats), find the weight of corn and bran needed to complete the ration.

3. If a heavily worked horse of 1200 lb. receives 10 lb. timothy hay and 8 lb. oats, find the balance of corn and bran needed.

4. Test the rule: 1 lb. concentrate and 1 lb. roughage for each 100 lb. of horse when the ration of 1200 lb. animal is corn stover, corn and bran.

5. Same when the ration is timothy hay, bran, corn and 8 lb. dried brewers' grains for 1500 lb. horse.

6. An 8 mos. lamb weighing 75 lb. receives 9 lb. corn silage a day. How much shelled corn and cottonseed meal are needed to make a balanced ration?

7. A 60 lb. sheep of 7 mos. gets 1.2 lb. mixed hay (average figures for timothy and clover) and 1.2 lb. roots (average the figures for mangels, carrots, and turnips). How much corn and bran are needed?

8. How much shelled corn and peas for the above?

9. A 1000 lb. cow yielding 22 lb. of average milk receives 20 lb. mixed hay and 3 lb. oats. Construct a balanced ration of corn meal and linseed meal.

10. Same for 40 lb. roots, 15 lb. corn stalks, 3 lb. oats, and the remainder wheat bran and gluten feed.

11. Same for 25 lb. corn silage, 5 lb. clover hay, 2 lb. oats and the remainder corn and cottonseed meal.

12. Same for 4 lb. oats and the remainder corn meal and alfalfa hay.

Kind of Feed	Per Cent Digestible	Nutritive Ratio
Roughage		
Fodder corn	13.5	1 : 12.5
Peas and oats fodder	9.4	1 : 4.2
Red clover	19.3	1 : 5.6
Alfalfa	17.7	1 : 3.5
Corn silage	13.8	1 : 14.3
Potatoes	17.4	1 : 18.3
Mangels	6.7	1 : 5.1
Sugar beets	11.5	1 : 9.4
Carrots	9.	1 : 10.3
Turnips	8.7	1 : 7.7
Timothy	49.3	1 : 16.6
Red clover hay	46.4	1 : 5.8
Alfalfa hay	53.3	1 : 3.8
Oat straw	41.6	1 : 33.6
Concentrates		
Corn (grain)	84.3	1 : 9.7
Wheat	83.2	1 : 7.2
Rye	79.9	1 : 7.1
Barley	77.9	1 : 7.9
Oats	66.	1 : 6.2
Peas	70.2	1 : 3.2
Corn and cob meal	70.9	1 : 15.1
Wheat bran	57.5	1 : 3.7
Wheat middlings	73.5	1 : 4.7
Rye bran	66.3	1 : 4.8
Brewers' grains, wet	16.4	1 : 3.2
Brewers' grains, dry	63.5	1 : 3
Linseed meal	77.8	1 : 1.7
Buffalo gluten feed	93.1	1 : 3
Chicago gluten feed	79.	1 : 1.5
Cottonseed meal	81.6	1 : 1.2
Skim milk	08.8	1 : 2
Buttermilk	10.4	1 : 1.7

Kind of Stock	Lb. Digestible material needed per 100 lb. live weight per day	Nutritive Ratio
Oxen at rest in stall	.90	1 : 11.9
Oxen moderately worked	1.20	1 : 7.5
Oxen heavily worked	1.67	1 : 6
Wool sheep, coarser breeds	1.20	1 : 9
Wool sheep, finer breeds	1.35	1 : 8
Horses, lightly worked	1.19	1 : 6.9
Horses, moderately worked	1.35	1 : 6.9
Horses, heavily worked	1.66	1 : 6.2
Milch cows yielding 11 lb. milk	1.23	1 : 6.7
Milch cows yielding 16.6 lb. milk	1.39	1 : 6
Milch cows yielding 22 lb. milk	1.66	1 : 5.7
Milch cows yielding 27.5 lb. milk	1.81	1 : 4.5
Fattening oxen	1.89	1 : 6
Fattening sheep	1.93	1 : 4.5
Fattening swine	2.80	1 : 6
Growing cattle, 2-3 mos. old	2.23	1 : 4.6
Growing cattle, 3-6 mos. old	1.90	1 : 4.9
Growing cattle, 6-12 mos. old	1.74	1 : 6
Growing sheep, 5-6 mos. old	2.06	1 : 5.4
Growing sheep, 6-8 mos. old	1.74	1 : 5.4
Growing sheep, 8-11 mos. old	1.46	1 : 6
Growing fat pigs, 2-3 mos. old	3.75	1 : 4
Growing fat pigs, 3-5 mos. old	3.00	1 : 5

Growing fat pigs, 5-6 mos. old	2.80	1 : 5.5
Growing fat pigs, 6-8 mos. old	2.38	1 : 6

Problems in Fertilizers.

Computation of food of plants, or fertilizing materials is similar in some respects to that of food for animals. Plants require, and fertilizers contain, three chief ingredients, nitrogen, phosphorus (phosphoric acid) and potassium (potash). While some soils may contain one or more of these elements in almost unlimited quantities, it is necessary in most cases to supply some or all of them by artificial means, either to build up soils naturally poor in these elements, or to maintain good ones at their original high state of production. The fertilizer requirements of a given soil are usually determined by a series of narrow test strips through the field, some treated with one element, some with another, and some with combinations of two or three. Where plants on the fertilized strip show no improvement over the unfertilized control, it is reasonable to assume that the natural supply of this ingredient is already sufficient. Enough of the other substances should be added each year at least to balance the amount removed by the crop.

The following tables, and similar data that can be found in agricultural books, reports, fertilizer analyses, etc., enable one to compute the amount and proportions of fertilizer ingredients needed for a given situation. In using these, a word of instruction may be necessary. The methods of stating some of the formulas, especially by some of the fertilizer manufacturers, is somewhat deceptive to the novice. Where equivalents are given, e. g., "nitrogen equivalent to ammonia," "phosphoric acid equivalent to bone phosphate," "potash, equivalent to sulphate of potash," etc., percentages must be reduced in the proportion indicated in our table of fertilizers. Phosphoric acid may be listed in the analysis as, (1) available (soluble), (2) reverted (citrate soluble) and (3) insoluble. The first is made from bone, phosphatic rock, etc., treated with acid so that the resulting phosphoric acid is soluble in water and therefore available for immediate absorption by the plant. The reverted has had similar treatment but by standing has lost its water solubility. The insoluble is raw rock, slag or bone, unavailable for plant food till released by the slow action of weather, decaying organic material in contact with the mineral and possibly root secretions of the living plants. The figures to be used, therefore, will depend upon whether quick results or permanent fertility is most important.

Fertilizing fields is such coarse work that a high degree of accuracy in the computation is not possible. Figures taken from different sources will vary considerably, as the grounds upon which tests are made vary. This, however, does not destroy the usefulness of computation to supplement judgment and experience, and any estimate carefully made is sure to be of value.

Illustrative Problem.

What quantities of dried blood (13 per cent nitrogen) and bone meal (3 per cent nit. and 24 per cent phos.) are needed for an acre of cereal ground, strong in potash, but requiring nitrogen and phosphoric acid in the proportions: 12 : 24 lbs. respectively.

Let x = no. lb. dried blood. $.13x$ = lb. nit. in dr. bl.
y = no. lb. bone meal. $.03y$ = nit. and $.24y$ = phos. in b. m.
Equation: $.13x+.03y$ = 12 lb. nitrogen required.
$.24y$ = 24 lb. phos. acid required.
Solving: y = 100 lb. bone meal; x = 70 (approx.) lb. dried blood.

Another Illustrative Problem.

A poultryman has a supply of wood ashes and also a limited quantity of hen manure which comes from the pens mixed with an equal weight of leaves. How much dissolved bone will he need to buy, and how shall he mix his own materials to the best advantage as a complete fertilizer for an acre of beets?

From the tables:

Analysis of hen manure:	2.	: 2.	: 1. %
Analysis of leaves	.7	: .15	: .3
Average of mixture	1.35	: 1.08	: .65 %
Expressed decimally:	.0135	: .0108	: .0065

Dissolved bone expressed decimally: .02 : .20 : 0
Wood ashes expressed decimally: 0 : .01 : .05
Required for an acre of beets: 20 lb. nit. : 25 lb. phos. : 35 lb. potash
Let m = number lb. mixed manure and leaves needed per acre
a = number lb. wood ashes needed per acre
b = number lb. dissolved bone needed per acre

$$\begin{aligned} \text{Equation: } .0135m+.02b &= 20 \text{ lb. nitrogen required} \\ .0108m+.20b+.01a &= 25 \text{ lb. phos. acid required} \\ .0065m+\phantom{.20b+{}} .05a &= 35 \text{ lb. potash required} \end{aligned}$$

Solving,

$$.0475m+1.00b = 90$$

m = 1450 (approx.) lb. mixture per acre.
b = 21 (approx.) lb. dissolved bone needed per acre.
a = 511 (approx.) lb. wood ashes needed.

Practice Problems in Mixing Fertilizers.

1. Substitute nitrate of soda and steamed bone for dried blood and bone meal in the first illustrative problem.
2. Substitute corn for beets in the second illustrative problem.
3. Compute the proportions of wood ashes and hen manure

for an acre of celery on peaty soil where nitrogen can be neglected.

4. A farmer has applied enough floats to his land to furnish a permanent supply of phosphate when released by the action of farmyard manure. What quantities of this manure supplemented with sulfate of potash are needed for raising onions?

5. A gardener has plowed 5,000 lb. farmyard manure under an acre of tomato land. How much dried ferns and wood ashes would complete the fertilization?

6. Work out a balanced fertilizer of acid bone and sulfate of ammonia for an acre of cabbage on clay land where potash can be omitted.

7. In what quantities would you apply marsh hay supplemented with soot and a 1 : 8 : 0 fertilizer for .01 acre patch of lettuce?

8. Work out a balanced fertilizer of fish guano and a mixture of equal weights of bone meal and superphosphate for an acre of turnips where potash can be neglected.

9. In what ratio would you mix acid bone and fish tankage to make a 2 : 8 : 0 complete fertilizer?

10. In what proportion can a man growing celery on land poor in potash afford to exchange barnyard manure for wood ashes?

POUNDS OF NITROGEN, PHOSPHORIC ACID AND POTASH PER ACRE.

(Minimum requirement. Double the figures for maximum.)

Cereals: barley, 12:20:25; buckwheat, 15:30:35; corn and sorghum, 10:35:30; oats and rye, 12:20:30; wheat, 12:20:12.

Garden crops: asparagus, 20:30:35; cabbage and cauliflower, 40:70:90; celery, 40:50:65; cucumbers, muskmelon, pumpkin, squash, watermelon, 30:50:65; egg plant, 40:50:90; lettuce, 40:50:75; onions, 45:55:80; radishes, 15:35:45; spinach, 15:55:40; tomatoes, 25:35:40.

Grasses: lawns, 20:25:30; meadows and millet, 15:30:35; pasture, 15:30:40.

Legumes: alfalfa and clover, 5:30:40; beans and peas, 5:30:35.

Orchards and small fruits: apples, pears and quinces, 8:30:50; blackberries, 15:30:40; cherries and plums, 10:35:45; currants and gooseberries, 10:25:40; grapes, 8:30:45; nursery stock, 10:25:30; peaches, 15:40:55; strawberries, 25:55:70.

Root crops: beets and turnips, 20:25:35; carrots, 15:35:40; horse radish, 15:25:35; parsnips, 20:55:50; potatoes, 30:40:65.

PERCENTAGE OF NITROGEN, PHOSPHORIC ACID AND POTASH IN COMMON FERTILIZING MATERIALS.

(Analyses vary considerably. Figures given represent rather high grade material. Commercial fertilizers are required by law to state formulas on the package.)

Nitrogenous: dried blood, 13:0:0; nitrate of soda (sodium nitrate), 15:0:0; sulfate of ammonia (ammonium sulfate), 20:0:0. In analyses and guarantees: ammonia = .82 nitrogen.

Phosphatic: acid phosphate (superphosphate, dissolved stone, acid stone), 0:16:0; basic slag (Thomas slag, iron phosphate), 0:15:0; floats (raw rock, raw phosphate, calcium phosphate, phosphate of lime), 0:12:0; acid bone black (dissolved bone black), 0:15:0.

Combined nitrogenous and phosphatic: acid bone (dissolved bone), 2:20:0; bone meal (ground bone, bone dust), 3:24:0; fish scrap (fish guano, fish tankage), 8:7:0; ground tankage (slaughter house refuse, meat guano), 7:9:0; steamed bone (degelatinized bone), 2:26:0; manure cake (rape cake, castor cake), 4:4:0.

Potash: muriate of potash (potassium chlorid), 0:0:50; kainit, 0:0:12; sulfate of potash (potassium sulfate), 0:0:45.

Combined phosphatic and potash: Wood ashes, 0:1:5; dry ferns, 0:3/8:1.8.

Combined nitrogenous, phosphatic and potash: corn stalks, 1/2:1/3:1 2/3; guano (peruvian guano), 5:18:3; cottonseed cake (cottonseed cake), 7:2 1/2: 1 1/2; farmyard manure, 1/2: 1/2:1/2; hen manure, dry, 2:2:1; leaves, .7:.15:.3; marsh hay, .8:.5:2.7; sheep manure, 2:1 1/2:1 1/2; straw, oat, .7:.2:1.1; straw, pea, 1:.3:1; soot, 2:1:1/4; compound manures (artificial fertilizers, complete fertilizers) various formulas: 1:8:0; 2:8:0; 2:8:1; 2:8:2; 4:8:2; 4:9:5; 11:5:1; 6:10:0, etc.

PIG IRON OUTPUT VALUED AT MORE THAN A BILLION DOLLARS.

The quantity of pig iron, exclusive of ferro-alloys, shipped or used by the producers in 1917, according to reports to the United States Geological Survey, amounted to 38,612,546 gross tons, valued at $1,053,-785,975, compared with 39,126,324 gross tons, valued at $663,478,118 in 1916, a decrease of 1.32 per cent in quantity and an increase of 59 per cent in value. The average price per ton at furnaces in 1917, as reported to the Survey, was $27.29, compared with $16.96 in 1916, an increase of 61 per cent. The production of pig iron, including ferro-alloys, was 38,647,397 gross tons in 1917, compared with 39,434,797 gross tons in 1916, a decrease of 4.5 per cent, according to figures published by the American Iron and Steel Institute, March 18, 1918.

AGRICULTURE AS PRESENTED BY SOME OF THE STATE NORMAL SCHOOLS.

By Oren E. Frazee,

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This summarized report is based upon information received from eighty state normal schools in response to a questionnaire addressed to one hundred three Presidents of such schools. State normal schools from each of the following geographical divisions of states were included in the mailing list:

North Atlantic	North Central	South Atlantic	South Central	Western
Me.	Ohio	Del.	Ky.	Mont.
N. Hamp.	Ind.	Md.	Tenn.	Wyo.
Vt.	Ill.	D. C.	Ala.	Colo.
Mass.	Mich.	Va.	Miss.	N. M.
R. I.	Wis.	W. Va.	La.	Ariz.
Conn.	Minn.	N. C.	Tex.	Utah
N. Y.	Ia.	S. C.	Ark.	Nev.
N. J.	Mo.	Ga.	Okla.	Idaho
Pa.	N. D.	Fla.		Wash.
	S. D.			Ore.
	Neb.			Cal.
	Kan.			

The eighty replies are believed to reflect the situation with respect to agricultural courses in the state normal schools of the country as covered by the questionnaire, since practically every state is included in the list of replies.

Questionnaire.

The department of biology of the St. Cloud Normal School desires as accurate a statement to the following questions as is possible to make in a limited space. We shall be glad to send a copy of the summary of replies to those who desire it:

1. In what courses is Agriculture required?
   Number of weeks required?
   In what year or years of the course?
2. What are the courses in Agriculture offered for six weeks or more?
3. What courses in other departments are prerequisites?
4. Check the types of schools in which your graduates are eligible to teach Agriculture.
   Rural Graded High School
5. Are graduates of other state schools offering Agriculture given preference by law in appointments to positions?
6. Do you believe that the Normal School should attempt to train teachers in both the art and the science of Agriculture?
7. What is the approximate value of your material equipment for Agriculture?
8. What coordination exists between your school and the community agriculturally?
9. Please make constructive suggestions concerning Agriculture in the Normal School:
   a. Its function.
   b. Relative rank.
   c. Probable trend.
   d. Desirable changes, etc.

In answer to "In what courses of the normal school is Agri-

culture required?" the data show that twenty-two schools (27 per cent) require agriculture in all courses (six describe the required work as Agricultural Nature Study, or Gardening). An observation of interest is that only four of the twenty-two normal schools requiring agriculture in all their courses are east of the Mississippi River. The eighteen remaining schools which require agriculture in all courses are widely scattered over the South Central and Western division of states. No schools from the North Atlantic division report agriculture in all of their courses. There are only four schools in the North Central and South Atlantic divisions which indicate in the replies that agriculture is required in all courses. Agricultural Nature Study, or Gardening, is required in all courses by six normal schools, four of which are located in the North Atlantic division, the remaining two are located in the North Central division.

In support of the plan to require agricultural training for the preparation of all teachers by normal schools, an instructor in a middle western normal school writes: "Every teacher should know something of this greatest of American industries, and certainly teachers of the rural and graded schools, besides the teachers of the biological sciences in the high schools, should be thus prepared."

The president of a normal school in the extreme west says: "I think it probable that all of our science work in the normal school will ultimately be tied up with agriculture and household economics. I believe its importance will be recognized more and more until it will become one of the most vital subjects in the curriculum."

An additional point of interest is that these twenty-two western normal schools, reporting that agriculture is required in all their courses, also indicate that normal schools should train students both in the art and science of agriculture.

"If the teacher of agriculture is to be of any value to the high schools of the state, or even rural schools," said one writer, from the North Central division, "he must be trained in the art and science of agriculture by the normal school." Another of the North Central division said, "I regret that our normal schools have not felt free . . . to train teachers for any phase of public school work including agriculture." A president of a western normal wrote: "Rural, graded, and high school teachers of agriculture must come from the normal schools. Graduates from agricultural colleges are entirely taken up with

other lines of work. With a little more equipment the normal schools can prepare teachers of agriculture better than the colleges." From very few was there corroboration of this view: "I firmly believe a normal school should stick to the job of preparing teachers for elementary school work. . . . I see no use trying to compete with and duplicate the plant of the state college." From the North Atlantic division, however, came a number of replies adverse to placing agriculture in the normal curriculum. These replies are epitomized by the following quotations: "It is foolish to teach agriculture (even as a science) in city schools. . . . We have more important things to do than teach appreciation of the farmer's service to the country. . . . One can form no adequate idea of the farm from a study of farm life in the city. I doubt the wisdom, even the possibility, of accomplishing much in the field so long as practically all of our students are young women."

Twenty-four schools (30 per cent) require agriculture in rural and graded school courses. The twenty-four schools requiring agriculture in the rural and graded school courses only are, with four exceptions, situated in the North Central division and in all cases, save two, their students are eligible to teach agriculture in the high schools. If we examine the total number of schools which may prepare teachers of agriculture for high school positions (see data on question 4) it is found that these thirty-eight schools are situated mainly in the North Central, South Central, and Western divisions. In some of these cases, however, it is stated that preference is given, though not necessarily through legal enactment, to the college trained teacher of agriculture. It works out in some instances after the situation in Illinois as stated by President W. P. Morgan of the Macomb State Normal. He says, "Graduates of other state schools are given preference to a degree, due to the fact that high schools to be accredited at the University must have a certain number of college graduates on their faculty."

Five schools (6 per cent) require agriculture in the regular course (possibly these should be included with the twenty-two above); three schools require it in agriculture and advanced courses only; two in science and household arts only; while it is reported as elective in two schools; and not required for any course in eighteen schools (22 per cent). One of these, however, makes it a requirement for admission. These eighteen schools are scattered over the entire country but more than 50 per cent

of them are located in the North Atlantic division. The most frequent explanation offered by those not requiring agriculture for any course is that their students are largely from the cities, and when the student has received his training he returns to the city to teach, hence it is impracticable to include agriculture in the curriculum. Some of these offer, but do not require it in every case, work in school gardening especially adapted to the city, or the suburban districts.

In tabulating the replies received to the question "Number of weeks Agriculture is required?" it was found convenient to group the replies under 12, 18, 24, 36, 48, 72 or more weeks, notwithstanding that this necessitated some approximations, for example, "One year is required" is counted 36 weeks, and "nine weeks" or "twenty-seven weeks" are counted 12 weeks or 24 weeks respectively; and fractional parts of a year are reduced to weeks before tabulation. The data show that ten schools require agriculture for 12 weeks; eleven schools require it for 18 weeks; four schools require it for 24 weeks; twenty-four schools require it for 36 weeks (40 per cent); four schools require it for 48 weeks; and eight schools require it for 72 weeks or more. Of these eight schools, two schools require agriculture for four years, and one requires agriculture each term in its five-year course. A study of these answers in relation to the answers to number one above reveals, first, that there is no school requiring agriculture in all of its courses which does not devote at least thirty-six weeks to the subject, while many schools require it for two years; second, that those requiring less than thirty-six weeks, especially those giving but twelve weeks, are the normal schools which have agriculture in the rural courses. These courses are frequently not more than twelve weeks in length.

In answer to "In what year or years in the course is Agriculture required?" the tabulation includes some schools which do not require agriculture but offer it as an elective in certain years of the course. The data show that fifteen schools place it in the first year; fifteen in the second; nine in the third; fourteen in the fourth; one in the fifth; seven require it every year (this number includes some having but two years normal training); and in fifteen schools it is optional with the student which year he pursues it.

"What are the courses in Agriculture offered for six weeks or more?" Such a great variety of similar expressions was used in

the replies to designate the same course that it seemed best to group those courses which are apparently alike. General agriculture (includes elementary agriculture) is taught for six weeks or more in forty-four schools (50 per cent); animal husbandry (includes farm animal courses) is taught in twenty schools; soils (includes courses in soil physics), eighteen schools; farm crops and cropping, thirteen schools, horticulture, thirteen schools; gardening, ten schools; agronomy, eight schools; dairy husbandry, seven schools; feeds and feeding, six schools; farm management, six schools; plant propagation (includes plant breeding), seven schools; poultry, four schools; stock judging, three schools; weeds, three schools; rural economics, three schools; farm mechanics, two schools; forestry, two schools; one school reports for each of the following subjects—methods in agriculture, economic entomology, bacteriology, plant pathology, agricultural chemistry. There is overlapping in these courses to some extent. For instance, in the case of the forty-four schools offering six weeks or more of general agriculture, a number of these offer certain special courses in the subject to follow the twenty-four or thirty-six weeks of general agriculture. Also, some schools differentiate their courses but frequently this may not cover any wider field than those schools which reported simply general agriculture. Differentiation of courses is prominent, however, in those schools of the South Central and Western divisions which require agriculture of all students. The following seems to be fairly typical of such differentiation. The school referred to requires agriculture of all students for one year. The subjects offered for six weeks or more are: a. General agriculture. b. Animal husbandry. c. Horticulture. d. Farm crops. e. Farm management. This makes it possible for students to secure a range in the selection of courses to suit their needs and still satisfy the time requirement.

"What courses in other departments are prerequisite to Agriculture?" There are forty-five normal schools (56 per cent) which admit students to the agricultural courses without any special prerequisite (six of these are schools which require agriculture in all courses); ten schools name biology as a prerequisite; seven schools require chemistry; seven schools require three to four years of high school work; botany is prerequisite in three schools; physics, in two schools; commercial branches, in two schools; physiography, in twelve schools; elementary agriculture, in two schools; zoology, in one school.

"Check the types of schools in which your graduates are eligible to teach Agriculture—Rural; Graded; High School." The tabulation of replies shows that sixty-three normal schools (79 per cent) prepare teachers of Agriculture for rural schools, three of which prepare for rural schools alone; 60 normal schools (75 per cent) may prepare teachers of agriculture for graded schools as well as for rural schools; thirty-eight normal schools (48 per cent) may prepare teachers of agriculture for high schools in addition to the preparation of teachers for the elementary schools.

With respect to the preparation of teachers of agriculture for the high schools, there seems to be a definite movement to do so in the North Central, South Central and Western divisions. In many of the schools of these sections the replies indicate an extension of the curriculum to include more agricultural training of the teachers. Many replies indicate, with expressions such as "after 1918," or "soon," that certain changes would obtain in their schools, the effecting of which would materially strengthen their agricultural department. Replying to the questionnaire, Professor U. O. Cox of the Indiana State Normal School at Terre Haute gave the following comment concerning the extension of the courses in that institution: "Our courses now for graduation are all four years in length, with a degree for each course. There is the regular college course, A. B., the normal course, Ph. B., and the vocational courses, B. S. (Household Economics, Industrial Arts, and Agriculture). . . . At present we are not giving all of the agriculture course but hope to do so very soon. We expect to have a farm fully equipped in the near future. We have a new building with special laboratories which is nearly ready." Obviously, from this and from similar replies, the normal schools are planning to enter this field of work to help supply the insistent demand of schools for better trained teachers of agriculture.

"Are graduates of other state schools offering Agriculture given preference by law in appointments to positions?" The replies of forty-three normal schools (54 per cent) indicate that there is no such statutory regulation in their respective states; five schools indicate "Yes"; five indicate "If position is in high school"; three indicate "Possibly university graduates are given preference." A few were not informed concerning the existence or non-existence of such provision.

"Do you believe that the normal school should attempt to

train teachers both in the art and the science of Agriculture?" The normal schools which responded to tnis are in substantial agreement that the normal school should do so. The replies indicate 70 per cent favoring while the remaining 30 per cent are about equally divided in opinion as follows: Ten schools indicate "No"; four schools in science only; two schools in art only; two schools, "Special schools (preferably normal schools). should be delegated to do the work in agriculture." While the number was large who believed that the training of teachers of agriculture by the normal schools should include training both in the art and science, many did not think the conditions were such that it could be effected at the present time. Some states, for example, have a number of normal schools, other states lack equipment, and some suggested that the best way out of the difficulty is to allow the technical schools to do all of this work. In this connection, the Wisconsin system of department specialization is favored in a number of the replies, all, however, from states similar to Wisconsin in that several normal schools serve the state.

The arrangement as described by President Cotton of the La Crosse Wisconsin Normal is: "Each normal school in the Wisconsin system has a specialized department. The schools at both River Falls and Platteville, Wisconsin, have the specialized department of agriculture. Graduates from these schools teach agriculture in the rural schools, state graded schools, and the high schools of the state." He added: "I believe that one or two normal schools in each state should attempt to train teachers both in the art and science of agriculture. I do not think it would be necessary to have all of the schools attempt so much when there are several normal schools in the state."

"What is the approximate value of your material equipment for Agriculture?" The data show that one normal school has an estimated material equipment of $100,000; five schools have approximately $50,000 each; seven have $10,000 each; eight with $5,000 each; nine have $1,000 each; fourteen have $500 each; six with $100 each; and five report, "Little or nominal."

"What coordination exists between your school and the community agriculturally?" Twenty-two schools (45 per cent) indicate that there is no coordination of the work of the school and the agriculture of the community; ten schools do club work, or cooperate with a county agent; nine schools do certain types of practical work, such as soil testing, determining species of

insects, suggesting building plans, etc.; six schools do extension work, including lectures, and conduct experiments; one normal school does supervision work in the teaching of agriculture in district schools.

"Please make suggestive criticisms concerning Agriculture in the normal school; a. Its function; b. Relative rank; c. Probable trend; d. Desirable changes." The replies to (a) are practically unanimous in the belief that the function of agriculture in the normal school is to develop in the minds of young men and women a point of view with respect to the problems of rural communities. This would include a training which would emphasize, first, the art and science of agriculture; second, an appreciation and understanding of rural problems; and third, practical problems. The minority of those who answered this question was divided largely between those who would attach importance only to the practical aspects of the problem, and those who would emphasize the science of agriculture, or the art of agriculture, alone.

In reply to (b) and (c) the sentiment of the majority seems to be reflected in the thought that agriculture has a "relatively growing importance" in the normal curriculum. One reply indicated that it would be dependent upon the final interpretation given to the "Smith-Hughes Act." A few replies indicated that "Home Project Work" would soon be much more general than now.

In reply to (d) the sentiment, aside from those having in mind purely local matters of administration, is, first, that the subject needs to be vitalized in the curriculum; second, that it should be more generally required; third, that it should be taught in the training school.

The questionnaire has determined that agriculture as a fundamental part of the normal school curriculum is not only acceptable but also that it is very rapidly developing to meet the needs of the schools of the community.

SHUNT MOTOR.

By E. C. Mayer,

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Part I. Introduction.

A. Comparisons of Generators and Motors.

Dynamo electric machines are generally divided into two classes, generators and motors. A generator is a machine which is supplied with mechanical energy, which it transforms and delivers as electric energy in the form of an electric current; a motor is a machine which is supplied with electric energy, which is transformed into mechanical energy, and as such is available at the pulley end of the motor shaft. Structurally, the two machines are alike. Each consists, if attention is devoted to direct current machines only, of field magnets, which are large electromagnets suitably mounted on iron cores attached to the field frame, and a revolving armature, consisting of a cylindrical iron core on whose outer periphery are many conductors, so arranged as to cut the magnetic lines of force emanating from the field electromagnets. Direct current machines are also provided with a commutator[1], and at least two brushes, by means of which connection is made with the external circuits.

Faraday's laws of electromagnetic induction state that a conductor, moving in a magnetic field so as to cut lines of force, is the seat of an electromotive force. The existence of this E. M. F. depends only upon the relative motion of the magnetic field and the conductor. That is, an E. M. F. is likewise produced in a stationary conductor by moving a magnetic field past it. So that in practice one finds generators with stationary field magnets and revolving armature, or vice versa.

B. Relation Between Impressed Voltage, Counter E. M. F., Flux, Speed, Current and Torque.

By a consideration of Fig. 1, which represents diagrammatically one conductor A, of an armature revolving between the field magnets, N and S, of a generator, according to Fleming's right-hand rule,[2] there is an induced E. M. F. developed in A which gives rise to a current in A in a direction perpendicular to the plane of the paper and towards the observer. A current flowing towards the observer is usually represented, as in the figure,

[1]A brief description of a commutator, together with its operation, is given in a previous experiment on the shunt generator.

[2]See experiment on Shunt Generator, School Science and Mathematics, Vol. XVII, No. 2, 1917.

by a dot (.); one flowing away from the observer is represented by (x). For simplicity, the diagram indicates the magnetic field as parallel rather than radical, as is usually the case in actual machines. Now the current which flows in A maintains its own individual magnetic field, which is a series of loops surrounding A, one of which is indicated in the figure. This magnetic field strengthens the field of the field magnets on one side of A (the lower side) and weakens and partially neutralizes it on the other side of A. Thus is seen why in a generator the field flux, due to the combined actions of all armature conductors, is crowded towards one pole tip (the trailing tip) of the field magnet. In a motor the action is reverse and the field flux is crowded towards the leading pole tip.

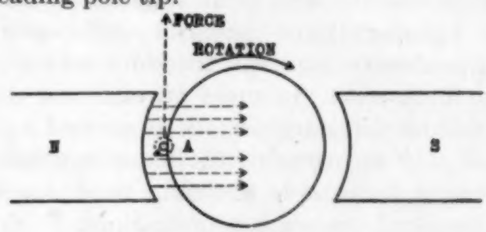


Figure 1

From the results of experiment, a conductor conveying a current and moving in a magnetic field so as to cut the lines of force experiences a mechanical retarding force, which is in the direction opposite to that of the motion. Thus, in Fig. 1 there is a force exerted upon the conductor A, vertically upward, which force produces a moment or torque which tends to oppose the rotation of the armature. And in order for it to revolve, the driving engine must be sufficiently able to turn the armature at the required rate in spite of the opposition due to the retarding torque. This may be considered a counter-torque. A rule known as Fleming's left-hand rule,[3] to give the direction of this mechanical force when the directions of external magnetic field and current are given, is as follows: Extend the thumb and first two fingers of the left hand so that they are mutually perpendicular. If the first finger is pointed in the direction of the field and the second or middle finger in the direction of the flow of current, the thumb will indicate the direction of mechanical force.

In the case of a motor, suppose a constant voltage is applied to the armature, such that current flows in A towards the observer as indicated in Fig. 2.

[3]Compare with Fleming's right-hand rule.

According to the above rule, the mechanical force on A and the other armature conductors will produce a driving torque which will cause the armature to revolve clockwise in the magnetic

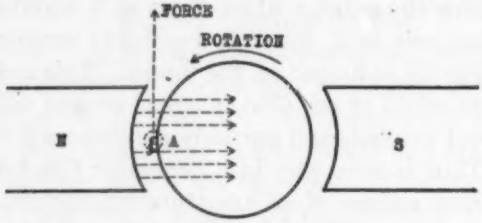


Figure 2

field between N and S. Now, since A is moving in a magnetic field, it will become the seat of an induced E. M. F., which, according to Fleming's right-hand rule, will be directed in A away from the observer and will therefore tend to oppose the original flow of current. In order to maintain the armature current, it will be necessary for the impressed voltage to be sufficient, not only to overcome the impedance offered by the armature winding, but also to overcome the induced E. M. F., which is technically known as a counter E. M. F. This may be expressed as follows:

(1) $E = E_e + R_A I_A$

where E is the constant[4] E. M. F. impressed at the brushes of the motor.

E_e[5] is the counter E. M. F.

R_A is the resistance of the armature circuit between the brushes.

I_A is the armature current.

The E. M. F., E_e, induced in the armature, has the same value as if the machine were functioning as a generator. It was shown[6] to be equal to $\phi NpZ \times 10^{-8}$ where ϕ is the flux emanating from one pole, N is revolutions per second (speed), p is number of poles, Z is total number of conductors in series between the two brushes, or

(2) $E_e = k\phi N$ where K is the constant $pZ \times 10^{-8}$

That is, counter E. M. F. is proportional to flux and speed. Substituting (2) in (1),

(3) $E = k\phi N + R_A I_A$ or

(4) $I_A = \dfrac{E - k\phi N}{R_A}$ or

[4]In this experiment the motor is assumed to be supplied with a constant impressed voltage. Motors are occasionally operated with constant current supply.

[5]E_e is in reality equal and opposite to the counter E. M. F.; in other words, it is that part of E necessary to overcome the counter E. M. F.

[6]See experiment on Shunt Generator, SCHOOL SCIENCE AND MATHEMATICS, Vol. XVII, No. 2, 1917.

(5) $$N = \frac{E - R_A I_A}{k\phi}$$

The value of the mechanical force discussed above, which a conductor conveying a current experiences when moving in a magnetic field, is liH dynes, when l is the effective length of the conductor in centimeters moving at right angles to its length, i is the current in c. g. s. units and H is the strength of the magnetic field in lines per square centimeter. Since torque, or the moment of a force about any point or axis, is defined as the product of the magnitude of the force and the distance from the point or axis under consideration, taken perpendicularly to the direction of the force, the torque which liH produces about the motor shaft is liH.r dyne-centimeters, where r is the mean radius of the armature in centimeters.

Consider the force liH exerted upon one conductor through one complete revolution. The work done is $liH \times 2\pi r$ ergs = torque$\times 2\pi$, where 2π is the angle turned through in radians. In N revolutions, the work done is torque$\times 2\pi \times N$; and if N = R. P. S., since power is defined as work done per second, the power P may be expressed as follows:

Power (P) = torque (T)$\times$total angle ($2\pi N$) turned through in one second

= torque$\times$speed$\times$constant

that is, torque is directly proportional to power and current and inversely proportional to speed. If P is expressed in H. P., T in pounds at a foot radius, and speed in R. P. M.,

(6) $$T = 5251 \frac{\text{H. P.}}{\text{R. P. M.}}$$

(7) $$T = 70.5 \frac{\text{watts}}{\text{R. P. M.}}$$

C. Discussion of Equations (4) and (5).

If a motor during operation is suddenly required to deliver a greater load, if the driving torque is insufficient, the motor will slow down. By means of equation (4) it is seen that, E and R_A being constants, a decrease in N will cause I_A to increase. Therefore, a larger armature current flows to produce the necessary greater torque to supply the larger output demanded of the motor. Under the condition of decrease in speed, E_o becomes less, and consequently the impedance to the flow of armature current is less than before. Likewise, in case I_A is too large for the load required, the driving torque, being also too

large, will cause the armature to revolve with continuously increasing speed, thereby causing N and E_e to become correspondingly larger. This larger value of E_e reduces I_A to exactly that value which will produce the necessary driving torque. Thus is seen how I_A automatically increases and decreases with increase and decrease respectively in load.

The various methods of controlling the speed of a motor are easily understood by reference to equation (5) and are as follows: The impressed voltage E may be varied: a regulating rheostat (in addition to the starting rheostat mentioned later, Part II, A) may be placed in series with the armature circuit, and by varying the resistance, R_A may be correspondingly varied; the flux, ϕ, may be changed either by varying the field current I_F by means of a rheostat in series with the shunt field winding, or with the field excitation constant, ϕ may be changed by offering greater or less resistance (reluctance) to the path of the magnetic flux. This is accomplished by a device which moves the field magnets farther from the armature, so as to increase the air gap, or vice versa, as the conditions demand. In the directions below, Part IV, C, the speed of the machine is varied by changing E.

The flux must never be reduced to a dangerously low value so that the motor will "race." For this reason the field must always be fully energized before the motor is started. Furthermore, during operation, the field circuit is always to be left closed.

Part II. Operation.

A. Starting and Stopping.[7]

Connect the motor to be operated as indicated in the accompanying diagram, Fig. 3. See that the field rheostat is set for zero resistance, and the starting armature rheostat for maximum resistance. A large field current is desirable in order to "stiffen" the field and thereby limit the speed, as discussed above. On starting, the armature is at rest and therefore E_e is zero. In order to limit the armature current to a safe value, a larger starting resistance is inserted in series with the armature, which is gradually cut out as the armature comes up to speed. Having made the proper connections, close the main switch and bring the armature up to speed by gradually cutting out the starting armature resistance. The speed may yet be further

[7]See appendix to Shunt Generator experiment, School Science and Mathematics, Vol. XVII, No. 2, 1917, for general directions on practical operation of dynamos.

increased by slowly increasing the field resistance until rated speed is obtained.

In order to stop the motor, increase the starting armature resistance from zero to the maximum value and open the main switch.

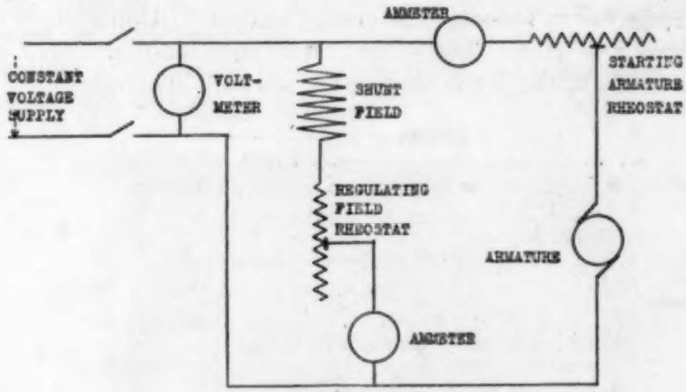


Figure 3

B. Questions.

1. In starting, why must the field circuit be closed *before* the armature circuit?
2. Why is a stiff or strong field necessary for starting?
3. Answer the same question with respect to starting under load.
4. How is the field current varied to increase and decrease the speed? Why?
5. Why is it dangerous to break the field circuit?
6. Why must the starting rheostat be connected in series with the armature and not with the line?

PART III. SPEED CHARACTERISTIC.

A. Data.

With the motor connected as indicated in Fig. 3, let the rated E. M. F. be impressed upon the brushes, and let this remain constant throughout the run. Also adjust the shunt field current I_F so that the motor runs at rated speed under no load. This value of I_F is to be maintained constant. Now by means[8] of drawing larger and larger current from a suitable generator belted to the motor, cause the motor load to vary from zero to full load, and in each case observe E, I_F, I_A and speed.

B. Curve.

Plot a curve with values of I_A as abscissa, and value of speed expressed in R. P. M. as ordinates. See Fig. 5.

[8]The load on the motor may also be varied by a brake or a blower.

PART IV. EFFICIENCY BY MEANS OF MEASUREMENT OF LOSSES.

A. *Classification of Losses.*

Efficiency of a motor may be defined as the ratio of the energy output to the energy input. In many cases, especially with respect to motors of large capacity, it is inconvenient or undesirable to measure the energy output.[9] Under these conditions the motor losses are determined and are then subtracted from the input to give the output. Therefore

$$\text{Efficiency} = \frac{\text{Input} - \text{losses}}{\text{Input}}$$

The losses of a motor may be classified as follows:

- Losses
  - Copper losses
    - Armature copper loss $R_A I_A^2$
    - Field copper loss $R_F I_F^2$ or $E I_F$
  - Rotation losses or stray power
    - Core or iron losses
      - Eddy current loss
      - Hysteresis loss
    - Friction or mechanical losses
      - Air friction or windage
      - Bearing friction
      - Brush friction

Both R_A and R_F are to be determined by the fall of potential method[10] when hot. Knowing I_A and I_F, the total copper losses may be readily found by computation.

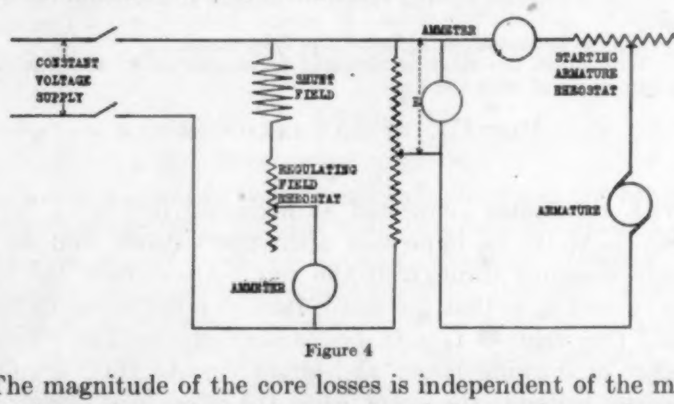


Figure 4

The magnitude of the core losses is independent of the motor load, depending only on the speed and the maximum flux density. At constant flux density, which in turn demands constant

[9]The output of a motor may be determined directly by electrical measurement by means of using a *belted* calibrated generator as load; or by mechanical measurement by means of determining torque by a Prony brake or Brackett cradle dynamometer. Power output is equal to the product of torque, speed, and a suitable constant. Compare equation (6) above. For a description of the Prony brake, see *Standard Handbook for Electrical Engineers*, 1915, pp. 192, 637. For a description of the cradle dynamometer, see *Standard Handbook for Electrical Engineers*, 1915, p. 195.

[10]See appendix, Shunt Generator experiment, loc. cit.

field excitation or constant value of I_F, the eddy current loss varies directly with the square of the speed, and the hysteresis loss varies directly with the speed.

The friction losses are also approximately independent of load and vary directly with the speed.

In order to determine the efficiency by the measurement of losses, two runs are made: the load run, to determine the working conditions, and the no-load run, to determine the losses under these same working conditions.

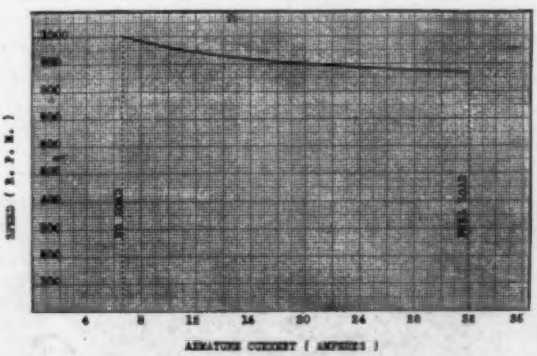


Figure 5

B. No-load Run.

1. Data.

The machine is driven electrically, according to the diagram of connections outlined in Fig. 4.

With constant field current, adjusted so that the motor runs at rated speed at no-load, vary the impressed voltage, E, from the rated value to approximately one-half rated value by ten equal steps, in each case measuring E, I_F, I_A and speed.

2. Losses.

With respect to the no-load run, the entire energy input is consumed in the losses of the machine. The total copper losses are computed as explained under Part IV, section A. The input, $E(I_A+I_F)$, minus the total copper losses, equals the rotation losses, W_o.

The results are to be tabulated as follows:

No-load Run.

Impressed voltage E	Current			Input EI_L
	Armature I_A	Field I_F (constant)	Line current $I_L = I_A+I$	

Copper Losses			Rotation Losses
Armature $R_A I^2_A$	Field EI_F	Total $R_A I_A^2 + EI_F$	$W_o = EI_L -$ total copper losses

Speed R. P. M.	Torque[11] = $\frac{W_o}{\text{R. P. M.}}$

3. Curves.

The following two curves are to be plotted: with speed expressed in R. P. M. as abscissas, plot value of W_o as ordinates for one curve, and values of torque for the second curve. The values plotted are found in the last three volumes of the preceding data table. See Fig. 6.

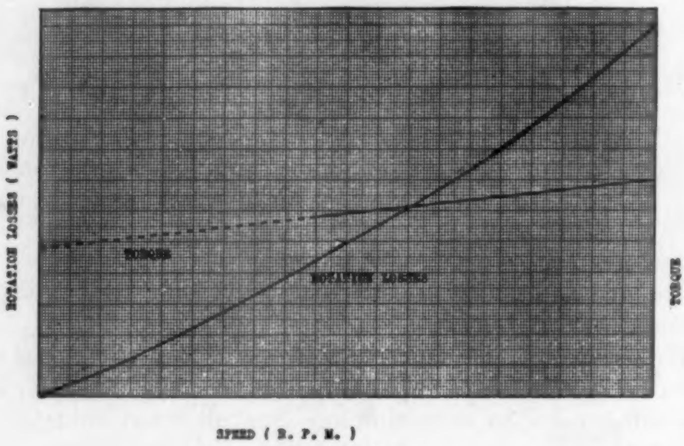


Figure 6

C. Load Run.

1. Data.

This run is identical with the run described to determine the speed characteristic. See Part III, A. The data for the load run is to be tabulated as follows:

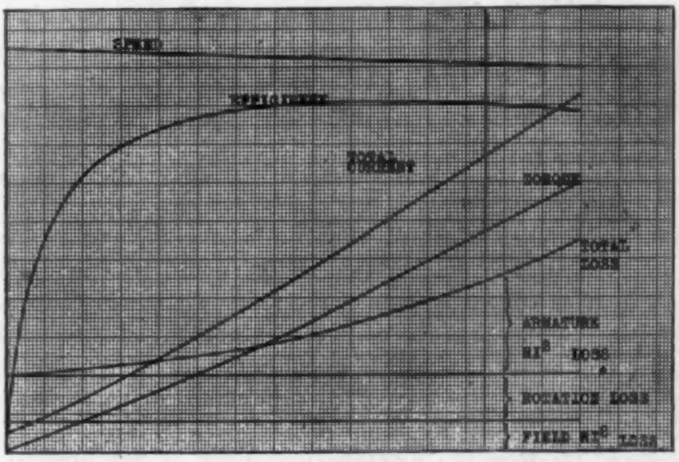
Load Run.

Impressed voltage E (constant)	Current			Input EI_L
	Armature I_A	Field I_F (constant)	Total $I_L = I_A + I_F$	

[11]Torque, as determined by the equation, is expressed in a unit called the "synchronous watt," if W_o is expressed in watts.

Copper Losses			Speed	Rotation losses
Armature	Field	Total		
$R_AI_A^2$	EI_F	$R_AI_A^2+EI_F$	R. P. M.	W_o[13]

Total losses	Output[13]	Efficiency =	Torque = W
W_o + copper losses	Input − total losses	$\frac{\text{output}}{\text{input}}$	$\frac{}{\text{R.P.M.}}$



POWER OUTPUT

Figure 7

2. Curves.

By means of the tabulated data, plot the following curves, in each case using values of power output or, more simply, armature current I_A as abscissas; field copper loss, armature copper loss, rotation losses, total losses, output, input, efficiency, total current, speed (already plotted under Part III, B), and torque. See Fig. 7. Interpret all the curves.

PART V. APPENDIX.

References.

Bedell and Pierce: "A. C. and D. C. Manual," 1914, pp. 25-35, 37-38, 41-49.

Franklin and Esty: "Elements of Electrical Engineering," 1906, vol. 1, pp. 95-116, 123-124, 127-128, 129-132, 138-139, 141-144, 172-175, 383-386, 408-410, 412-415.

Gray: "Principles and Practice of Electrical Engineering," 1914, pp. 78-90, 95-99, 105-113, 371, 373, 374.

[13]Obtained by reference to curve, Fig. 6.

A MODERN QUEST FOR THE PHILOSOPHER'S STONE.

In the Realm of Teaching the Secondary School Sciences.

By Herbert Brownell,

University of Nebraska, Lincoln.

At the 1917 meeting of the Central Association of Science and Mathematics Teachers a committee was continued to consider the question of "Science in the High School of Tomorrow." In School Science and Mathematics of June, 1917, this committee asked the assistance of all science teachers in the solution of certain named "problems," among which are to be noted:

A "unified" four-year course for secondary schools in contrast with "a train of specialized sciences."

"A unifying principle for such a course."

"The formulation of an aim, or aims, in the teaching of a unified science course."

"A minimum list of topics from each specialized science for incorporation into the course in introductory science." (Of these specialized sciences, *seventeen are named by way of suggestion.*)

In this further effort at the hands of this very competent committee, science teachers generally should be enough interested to offer suggestions as requested. Their assistance is invoked to the end that the continued search for this educational Philosopher's Stone may yield much in the teaching of secondary school sciences in the way of by-products, though it fail in its main purposes as set forth above.

Science teachers are wont to feel more or less indulgent in their discussions of the labors of those whose names are associated with the beginnings of chemistry as they sought to attain the transmutation of metals. We, too, feel ourselves rather superior in our greater enlightenment as we retell the story of the search for the Fountain of Perpetual Youth. We magnanimously allow that out of these efforts of alchemist and traveler have come much of progress in science and in civilization as by-products of efforts made by them.

Out of discussions, now largely forgotten, in the meetings of science teachers, from numberless papers and published articles containing the results of efforts much like that proposed by this committee, it would seem at first thought that little of lasting value has ever come. Nevertheless, in a community of interests established and in a unification of effort for the solution of the common problems of teachers of science in secondary schools, there is, indeed, a promise of gain worth all the time and pains of the committee and of those who respond to its call for suggestions and assistance.

The writer desires in this connection to express the belief that much of the lack of complete success heretofore, of attempts to unify the secondary school sciences and the root of much of the failure charged against them, *lies in choice of a unifying principle.* It is, perhaps, somewhat trite to say that the personality and preparation of teachers, the varied experiences and different natures of pupils, and the widely different conditions under which instruction in science in high schools occurs, are all variable factors in a problem *the solution of which can never be more than an approach to a constant.* To ignore these variables in any choices of topics made from the differentiated secondary school sciences is to court failure in practice. The unifying element for beginners in science must ever be the human element. As such, the problem is ever a difficult one, and the solution of it impossible of reduction to any system free of weaknesses that threaten its destruction. College and university science teaching is expected to be scientific in its presentation, and "science for its own sake." But in elementary science teaching the facts, phenomena and theories *are but material for the teaching of "folks."* It is the difficult task of the high school teacher to know when and how to bring about a transition in the spirit and procedure of science teaching from the objective to the subjective, from the inductive to the deductive.

One of the chief products of long continued efforts through committees to attain better results in science teaching has been an ever enlarging recognition of the fact that in all diversities of subject matter and in all methods of instruction in the various science branches there is to be found, in teaching them to high school boys and girls, a real unity *in the common interests and experiences of youth.* One common aim and end in the teaching of them all is the attainment of a scientific attitude of mind and a scientific procedure in all affairs of life. To organize the teaching of secondary school sciences on any plan which does not recognize as fundamental such choices of subject matter as shall arouse in pupils *a desire to know more,* which fails to stimulate and direct aright such desires with largest effectiveness, is to fall far short of a possible goal. Perhaps nowhere in the educational system is there so great need of skilled teaching as in the secondary school sciences. Success or failure in training each generation of youth to become intelligent observers of their surroundings in the natural world, capable of interpreting and applying in a scientific way the facts of experiment and of

observation, *requires as teachers* those who can quicken and direct the thinking of pupils, and in the routine of laboratory and classroom can secure the formation of study habits making of these pupils lifelong students. The quest for such teachers in sufficient numbers for the public school service goes on unendingly—a search for a human agency whereby untrained minds may be helped to acquire much of scientific capabilities and powers through studies in elementary science. No set of outlines, no selection of topics from the various divisions of secondary school science, however wisely chosen and combined, can be a substitute for a teacher who guides and inspires, one competent primarily *to teach folks as distinguished from teaching subject matter.* Herein is the handicap of the specialist in any science, and reason for his inability oftentimes to make lifelong students out of his high school pupils. Not enough attention, by far, is being given by science committees and science organizations to a quest for competent teachers of high school sciences to fill ranks depleted season by season. It seems to be taken for granted that in some unexplained manner such teachers will spring up out of the ranks or "grow up," even as did Topsy. No mechanism of outlined topics, of text and of manual, will accomplish what is desired in elementary science teaching in the hands of indifferently prepared teachers.

However, with all this emphasis placed upon the aims of the beginning phases of science teaching, and of the procedure necessarily followed to accomplish these aims, what the committee proposes to undertake is none the less important. This is especially the case in view of the need of an orderly transition from a science teaching that seeks primarily to get classes of pupils "to want to know" the teachings of science, and able to formulate and solve their own particular problems in life by reason of their science studies, to those later and more advanced stages where knowledge is presented and tested according to accepted theories, regardless of whether or not it has for the student any considerable measure of interest, of personal experience, or of application to his daily round of life.

The writer believes that a most helpful contribution was made not so very long ago to what this committee has under consideration, at least so far as the beginning stages of secondary school science is concerned, in a Bulletin published by the Massachusetts State Board of Education on "The Teaching of General Science." It is a manual of fifty pages for use of the teachers

of this late arrival in the list of high school science subjects, and sets forth admirably the spirit and aims of elementary science teaching. It can be made to serve as a starting point for the labors of this committee.

CONTAINERS FOR INSECTS AND BIRDS TO BE USED FOR CLASS WORK.

By Hattie J. Wakeman,

Zoological Laboratory, University of Wisconsin.

Though dried insects and bird skins offer excellent material for laboratory study in general biology, entomology, and parasitology courses, the best specimens usually cannot be put in the hands of students because they will be injured by careless treatment. In this laboratory we have lately used two schemes which obviate this difficulty and permit the use of the most valuable specimens by elementary classes.

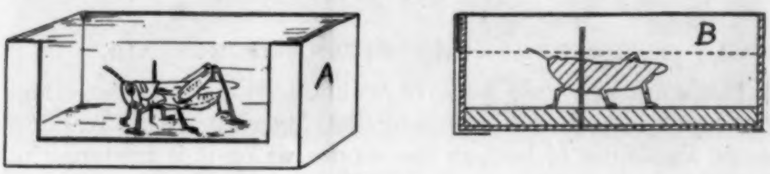
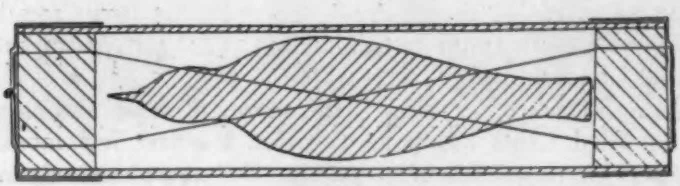


Figure 1

For insects a pasteboard box (Fig. 1) is made of appropriate size. This has a bottom of sheet pith, which receives the pin bearing the insect. Two sides and the top of the box are covered with sheet celluloid as glass plates and this allows students to examine the venation of wings and other details which require

A.



B.

Figure 2

the use of a hand lens. Ordinary insect pins will need to be cut off above the specimen in order to bring it close to the cover. The pith, pasteboard, and celluloid are firmly fastened together with passe partout, which also seals up the box and prevents the entrance of dermestids. If a drop of chloroform is placed in the box before it is closed, there need be no worry concerning the insect pests which so often destroy dried specimens.

Mr. A. H. Conrad, of the Crane High School, Chicago, devised an excellent method of preparing bird skins for class use (Fig. 2). Fine wires are threaded through the skin so that it can be fastened to corks in the ends of a glass tube of proper size to make a snug fit for the skin. A little chloroform is placed on the skin and the ends of the tube are sealed with passe partout.

Fig. 1. Insect box with two sides and top made of sheet celluloid or glass. A, entire box; B, section.
Fig. 2. Bird skin enclosed in glass tube for class work. A, entire preparation; B, section.

PHARMACY AS AN AMERICAN RED CROSS AID.

Pharmacy and the science of healing have played a large and invaluable part in the war, and the American Red Cross has made ample use of both in the service which it is rendering to humanity on behalf of the American people, whose steward it is. Essentially an agent of service, the Red Cross work originally was confined to hospitals, where the pharmacist and the surgeon worked hand in hand. Now that the scope of the Red Cross has taken in humanitarian efforts—the feeding of the hungry, the clothing of the naked and the housing of the homeless—the pharmaceutical-surgical side has been more or less overlooked by the public, yet it is as important as ever. It means the saving of lives and the rehabilitation of society.

The extent of the pharmaceutical side of Red Cross service may be gleaned from the fact that during the last few months it has shipped overseas 231,000,000 surgical dressings; that every month 1,000,000 pounds sterilized gauze and 10,000 pounds of ether go "over there." To date, the Red Cross has sent 10,637,201 hospital garments and 8,203,120 packages of hospital supplies.

Further evidence is shown by the supply of drugs and chemicals the Red Cross has bought within the last few months: 1,101,000 Greeley units of strychnine and morphine sulphate; 120,000 pounds nitrate ammonium; 390,000 pounds ether;

300,000 cathartical compositae pills; 52,500 pounds chloroform; 583,523 vials anti-tetanous serum; 640,000 sulphonol tablets; 11,000,000 strychnine sulphate tablets; 770,000 tablets of sodium salicylate and 350 ounces of apothesin.

Typical condition of a village in France when the American Red Cross starts its reconstruction work.

Major Perkins, Red Cross Commissioner for Europe, on the left, inspecting the American Red Cross transportation service.

This and much other quantity of drugs was used in Red Cross hospitals in France and elsewhere. Appropriations of the Red Cross for hospitals within the actual fighting zones amounted to $3,102,807 this year. Hospitals behind the lines and supplies cost $5,874,392. The equipment of civil hospitals for Belgian refugees in France cost $59,962. There are more than 7,000 beds available for American wounded in and about Paris. Many thousands of beds in tents, hospitals and in temporary buildings are right behind the advancing battle lines. There are six dispensaries and eight infirmaries at rest stations. There are eight convalescent homes for American soldiers.

At the American Red Cross laboratory, 10 Rue de Tilsitt, Paris. Assembling Burlingame units to send to the Front. The Burlingame unit is a box containing an emergency set of surgical instruments for surgeons behind the lines. July, 1918.

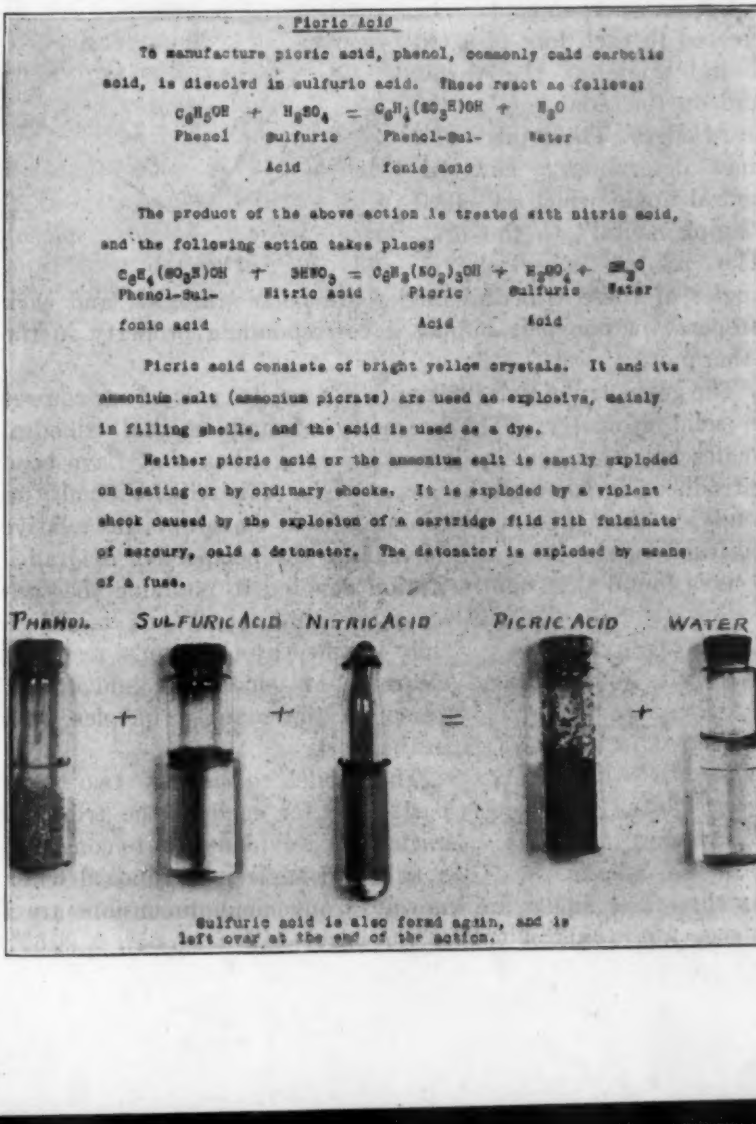
The Red Cross is operating eight hospitals on its own account and in connection with the army. In addition, it operates a tuberculosis sanitarium for soldiers, another similar institution for civilians and has a dozen hospitals for children in various parts of France. Then, too, it has dispensaries and diet kitchens and sixteen magnificently equipped hospital trains.

To date the Red Cross has received more than $325,000,000 from the American people in money and supplies. The service of the Red Cross is broadening daily as the number of our men overseas is increasing, as thousands are repatriated, as French and Belgian and Balkan territory is reclaimed. The Red Cross

must continue its service work for humanity. To do so it must have the united support of the American people. Accordingly it has set aside the week of December 16 to 23 for its second annual Christmas Roll Call. It is hoped that then every American will become a member of the Red Cross as a reconsecration of the people, an inspiring reassertion to mankind that in this hour of world tragedy, not to conquer but to serve is America's supreme aim.

PICRIC ACID MANUFACTURE.

By Harry C. Doane,
Grand Rapids.



Picric Acid

To manufacture picric acid, phenol, commonly cald carbolic acid, is dissolvd in sulfuric acid. These react as follows:

$$\underset{\text{Phenol}}{C_6H_5OH} + \underset{\text{Sulfuric Acid}}{H_2SO_4} = \underset{\text{Phenol-Sulfonic acid}}{C_6H_4(SO_3H)OH} + \underset{\text{Water}}{H_2O}$$

The product of the above action is treated with nitric acid, and the following action takes place:

$$\underset{\text{Phenol-Sulfonic acid}}{C_6H_4(SO_3H)OH} + \underset{\text{Nitric Acid}}{3HNO_3} = \underset{\text{Picric Acid}}{C_6H_2(NO_2)_3OH} + \underset{\text{Sulfuric Acid}}{H_2SO_4} + \underset{\text{Water}}{2H_2O}$$

Picric acid consists of bright yellow crystals. It and its ammonium salt (ammonium picrate) are used as explosive, mainly in filling shells, and the acid is used as a dye.

Neither picric acid or the ammonium salt is easily exploded on heating or by ordinary shocks. It is exploded by a violent shock caused by the explosion of a cartridge fild with fulminate of mercury, cald a detonator. The detonator is exploded by means of a fuse.

Sulfuric acid is also formd again, and is left over at the end of the action.

A MODEL OF SUPPLEMENTARY TRIHEDRAL ANGLES.

By R. M. Mathews,
Duluth, Minn.

When the vertices of a spherical triangle are joined to the center of a sphere, a trihedral angle is determined whose face angles are measured by the sides and whose dihedral angles are measured by the angles of the spherical triangle. The two figures may be called "related." Each property of a spherical triangle implies a corresponding property in the related trihedral angle. Conversely, when a trihedral angle is placed with its vertex at the center of a sphere, its edges cut the surface in the vertices of a related spherical triangle.

Let a perpendicular be erected to each face of a trihedral angle at the vertex and on the same side as the third edge. These three new lines determine a new trihedral angle which is called "supplemental" to the first. The related spherical triangles of these trihedral angles are polar triangles, and each property of one pair implies a corresponding property in the other pair.

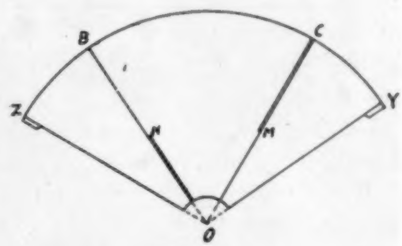


Figure 1

The geometry of polar triangles is a regular part of our courses in solid geometry. The geometry of supplemental trihedral angles has been neglected until recently, when they have been introduced in some of the newer texts. The chief difficulty in studying them lies in obtaining a clear image of the relative positions of the lines and in making the perspective diagrams. I have found that one recitation devoted to planning the construction of a cardboard model is fully justified by the pupils' resulting clearness of conception and firmer grasp on the many principles used in the work.

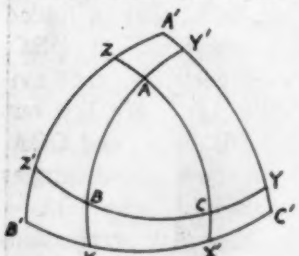


Figure 2

The model consists of two main parts, one for each of the trihedral angles. It is evident how to construct a trihedral angle in cardboard when its three face angles are known. Convenient dimensions are 4 inches for radius of sphere (or edge) and $a = 65°$, $b = 55°$,

$c = 50°$ for the face angles of the initial figure. Each face must have extensions on it, however, to hold it in proper position. To make face a, construct a sector BOC (Fig. 1) with an angle of 65° and a radius of 4 inches. Lay out a right angle COZ′ on the same side as OB, and right angle BOY on the same side as OC. Cut slots CM and ON half the length of the edges and equal in width to the thickness of the cardboard. Around 0 cut out a sector of 1-2 inch radius, to make the assembling easier, and leave small lugs at Y and Z′. In a similar fashion faces b and c are prepared and the three are assembled. It is well to mark the six corners (as X, X′, etc.) with the notation indicated in Fig. 2, for guides when this part is placed in the other one.

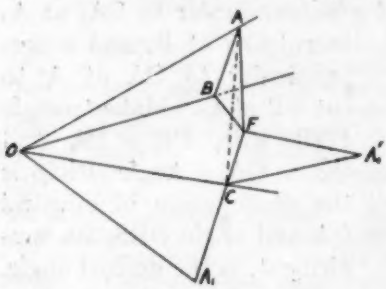


Figure 3

The face angles of the second trihedral angle are supplementary to the opposite dihedral angles in the initial trihedral. We must determine these. Through a point A on edge OA pass two planes, the one orthogonal to edge OB and the other to edge OC of the trihedral angle (Fig. 3). These planes intersect in a line AF which is normal to face BOC. Accordingly, triangle AFC is right angled at F and its angle C is a plane angle of the dihedral OC.

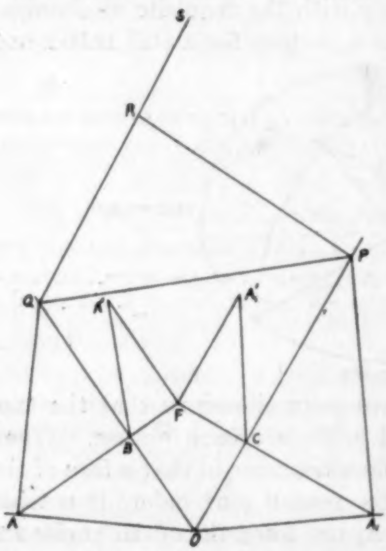


Figure 4

When this figure is folded out on the plane of OBC, the constructions are evident (Fig. 4). We lay out angles AOB, BOC and COA_1 equal to the initial angles respectively. Take OA = OA_1. Draw AB perpendicular to OB and A_1C perpendicular to OC meeting at F. Construct a right angle at F and make $CA'_1 = CA_1$. Then angle FCA'_1 is the plane angle of dihedral OC, and $A'CA_1$ is its supple-

ment. Similarly, angle ABA′ is obtained. The supplement for dihedral angle OA can be obtained by a like construction, or more quickly as follows: Erect a perpendicular to OA_1 at A_1 to cut OC at P; and a perpendicular to OA at A to cut OB at Q. Make triangle PQR with PR = PA and QR = QA. Angle PRQ is the plane angle of dihedral OA and angle PRS, its supplement, is the desired angle.

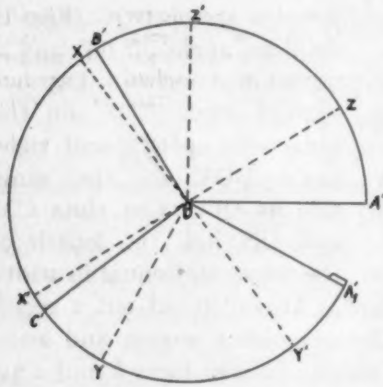


Figure 5

These three supplementary angles are the face angles of the new trihedral. Lay them out consecutively as A′OB′, B′OC′, C′OA′₁, and cut out the sector A′OA′₁ with a lug at A′₁. Draw lines OX perpendicular to OC′, OX′ perpendicular to O B′, and so on as indicated by Fig. 5 following the notation of Fig. 2. Crease along OB′ and OC′ and fasten together at A′A′₁. Now the two parts can be assembled and the model completed.

Should the class contain a boy with the requisite mechanical skill, this model can be used as a pattern for a still better one made of wire.

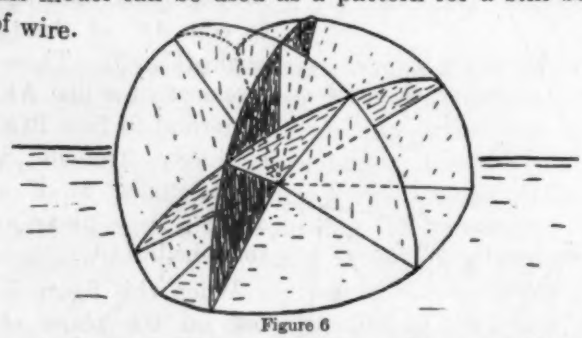


Figure 6

The angles as given here have been chosen so that the face angles on the second trihedral angle are each obtuse. When one of them is acute, certain difficulties arise in that a face of the first part intersects a face of the second part before it reaches the face to which it is normal. Again, when the initial angles are such that F falls, not in angle BOC but in its vertical angle, certain modifications of procedure are necessary. These diffiiculties can be surmounted without much trouble; to discuss them here would complicate a first presentation too much.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, and brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.*

SOLUTION OF PROBLEMS.

Algebra.

571. *Proposed by Harold M. Lufkin, St. Andrew's School, St. Andrew's, Tenn.*

Solve: $2\sqrt{2x+2}+\sqrt{2x+1} = \dfrac{12x+4}{\sqrt{8x+8}}$.

No communications concerning this problem were received. The problem as it is stated has no solution. If cleared of fractions and radicals the value $x = 1/7$ is found, which does not satisfy the equation. If the second radical is replaced by $-\sqrt{2x+1}$, $1/7$ is a root.—*Editor.*

Geometry.

572. *Proposed by Takeshi Omachi, Sendai, Japan.*

Catalan's Theorem: In a quadrilateral ABCD, if the sides AB and CD are equal to each other, the straight line MN passing through the middle points M and N of the sides BC and AD will equally incline to the sides AB and CD.

I. *Solution by Philomathe, Montreal, Canada.*

Draw NE equal and parallel to AB, also NF equal and parallel to CD. Join BE, EF, FC; EF passes through M and EM = MF (BEFC a parallelogram). Hence, in the isosceles triangle ENF, the line MN bisects the vertical angle N, that is MN is equally inclined to AB and CD.

II. *Solution by A. MacLeod, Aberdeen, Scotland.*

Draw AP, BQ, CR, DS perpendicular to MN, AK perpendicular to BQ, and DH perpendicular to CR.

From triangles APN, DSN, AP = DS $\therefore$ KQ = HR.

From triangles BQM, CRM, BQ = CR $\therefore$ BK = CH.

From triangles BAK, CDH, $\angle$BAK = $\angle$CDH, and these are the inclinations of AB and CD to MN.

Also solved by the Proposer, L. E. A. Ling *and* R. M. Matthews.

573. *Proposed by Clifford N. Mills, Brookings, S. Dak.*

From one of the angles of a rectangle a perpendicular is drawn to its diagonal, and from the point of their intersection straight lines are drawn perpendicular to the sides which contain the opposite angle. Show that if a and b be the lengths of the perpendiculars last drawn, and c the diagonal of the rectangle,

$$a^{\frac{2}{3}}+b^{\frac{2}{3}} = c^{\frac{2}{3}}.$$

I. *Solution by Philomathe, Montreal, Canada.*

Let m, n be the sides of the rectangle respectively parallel to b and a. Well known relations in the triangles give at once the equations,

$m^2+n^2 = c^2$, $bc/m^2 = m/c$, $ac/n^2 = n/c$.

Eliminate m and n from the system:

$bc^2 = m^3$, or $b^{\frac{2}{3}}c^{\frac{4}{3}} = m^2$; $ac^2 = n^3$, or $a^{\frac{2}{3}}c^{\frac{4}{3}} = n^2$; hence,

$a^{\frac{2}{3}}c^{\frac{4}{3}}+b^{\frac{2}{3}}c^{\frac{4}{3}} = m^2+n^2 = c^2$, or $a^{\frac{2}{3}}+b^{\frac{2}{3}} = c^{\frac{2}{3}}$.

II. *Solution by A. MacLeod, Aberdeen, Scotland.*

Given: Rectangle ABCD, AO $\perp$ BD, OE $\perp$ BC, OF $\perp$ CD.

To prove if OE $= a$, OF $= b$, BD $= c$, then $a^{\frac{2}{3}}+b^{\frac{2}{3}} = c^{\frac{2}{3}}$.

Let $\angle$ABD $= \theta$. Then $\angle$DAO $= \theta$.

OE = OB$\cos\theta$ = AB$\cos^2\theta$ = BD$\cos^3\theta$. $\therefore a = c\cos^3\theta$.

OF = OD$\sin\theta$ = AD$\sin^2\theta$ = BD$\sin^3\theta$. $\therefore b = c\sin^3\theta$.

$\therefore a^{\frac{2}{3}}+b^{\frac{2}{3}} = c^{\frac{2}{3}}\cos^2\theta+c^{\frac{2}{3}}\sin^2\theta = c^{\frac{2}{3}}$.

III. *Solution by L. E. A. Ling, La Grange, Ill.*

Given rectangle ABCD, DE $\perp$ AC, EM $= b$ and $\perp$ BC; EH $= a$ and $\perp$ AB; HE intersecting CD in L, EL $= k$; ME intersecting AD in N, NE $= g$; AC $= c$.

From the right triangle ACD,

$$c^2 = a^2+2ak+k^2+b^2+2bg+g^2. \qquad (1)$$

Rectangle NELD is equal to rectangle EHBM.

$\therefore gk = ab$, also $g = \sqrt{ak}$, $k = \sqrt{bg}$. Then $k\sqrt{ak} = ab$, whence $k = a^{\frac{1}{3}}b^{\frac{2}{3}}$. Similarly, $g = a^{\frac{2}{3}}b^{\frac{1}{3}}$. Substituting these values for k and g in (1),

$$c^2 = a^2+b^2+3a^{\frac{4}{3}}b^{\frac{2}{3}}+3a^{\frac{2}{3}}b^{\frac{4}{3}}. \qquad (2)$$

Taking the cube root of (2),

$c^{\frac{2}{3}} = a^{\frac{2}{3}}+b^{\frac{2}{3}}$.

Also solved by R. M. Mathews, *who appends the following remark:*

"When a line of constant length moves with its ends on two rectangular axes it envelopes a curve whose equation is

$x^{\frac{2}{3}}+y^{\frac{2}{3}} = c^{\frac{2}{3}}$.

This problem furnishes a construction for the point of contact of the line with its envelope."

574. *Proposed by N. P. Pandya, Amreli, Kathiawar, India.*

Construct a triangle ABC, having given the distances of its incentre, circumcentre, and orthocentre.

Solution by the Editor. (No solutions received.)

Let AI, AH, AO be given distances from vertex A of triangle ABC to incenter I, orthocentre H, and circumcentre O, respectively.

Lemma I. The distance AH is twice the distance from O to the side BC.

Lemma II. If R and r be the radii of the circumcircle and incircle, respectively, and $d(=\text{IO})$ the distance between the centers, $d^2 = \text{R}^2-2r\text{R}$.

Proofs of these lemmas may be found in Vol. XV, pp. 258, 259 (March, 1915), School Science and Mathematics, if not elsewhere.

Choose a point O as center and draw circumcircle with radius OA.

With radius AH/2 and center O describe circle which (by Lemma I) will be tangent to side BC. This lies within circumcircle, for the orthocenter of any triangle ABC is the circumcenter of a triangle A'B'C' formed by drawing lines through A, B, C parallel respectively to BC, CA, AB. Then, $AH < R'$ and $R' = 2R$, $\therefore AH/2 < R$. (R' circumradius of A'B'C'.)

Draw chord of circumcircle tangent to inner circle and choose this as side BC of the desired triangle. Angle A is thus determined.

Construct an angle equal to $\angle A$, bisect it, choose length AI on bisector, and drop perpendicular from I to one side determining r.

Construct d, a mean proportional between R and $R-2r$. (Lemma II.)

The intersection of a circle with radius d and center O with a line parallel to BC at the distance r from BC is the center I of the incircle. The intersection of a circle with center I and radius IA with the circumcircle will give the third vertex A of the triangle.

Proofs not contained in the statements are obvious.

575. *Selected.*

Prove this theorem from Wentworth-Smith's *Solid Geometry* (Exercises on Book VI) by means of earlier theorems.

If the face angle AVB of the trihedral angle V-ABC is bisected by the line VD, the angle CVD is less than, equal to, or greater than half the sum of the angles AVC and BVC according as CVD is less than, equal to, or greater than a right angle.

Solution by Philomathe.

In the plane CVD make angle DVC' equal to DVC. Trihedral angles V-ADC and V-BDC' are equal, hence angles BVC' and AVC are equal. Now, if angle $CVD < 90°$, the trihedral angle V-BCC' gives angle $CVC' < BVC' + BVC$, or $CVC' < AVC + BVC$, that is $CVD < 1/2(AVC + BVC)$.

Next, if angle $CVD = 90°$, CVC' is a straight line, then $BVC' + BVC = 180°$, or $AVC + BVC + = 180°$; hence $CVD = 1/2(AVC + BVC)$.

Finally, if angle $CVD > 90°$, then $CVC' > 180°$. Producing through V, AV to VA', BV to VB', and DV to VD', $CVD' < 90°$; hence $CVC' < CVA' + CVB'$ in trihedral angle V-A'B'C. $\therefore 360° - CVC' > (180° - CVA') + (180° - CVB')$, or $CVC'(\textit{reflex}) > CVA + CVB$.

Also solved by L. E. A. Ling. *R. M. Mathews calls our attention to the fact that this was solved as No. 404 in January, 1915. The two solutions published then differ from the one above.—Editor.*

Explanatory Note—*Problem* 567.

Contributed by Philomathe, Montreal, Can.

567. *Proposed by N. P. Pandya, Amreli, Kathiawar, India.*

Circumscribe a triangle about a given circle, the ratio of the angle bisectors being known.

In 1857-58, Catalan proposed the following problem: "To construct a triangle knowing its three bisectors." Nobody solved it. However, by analysis, Professor Barbarin proved that the solution depends upon an equation of the 12th degree! See *Mathesis*, 1896, pp. 143, 154; also *Intermediaire des Mathematiciens*, 1904, p. 229, Question 2771.

Now, No. 567 is correlative to Catalan's problem, and the solution of the former presupposes that of the latter. Therefore, I do not think the problem geometrically possible.

569. *Proposed by N. P. Pandya.*

The vertex A of a triangle is the center of a given circle. P and Q are points of intersection of AB, AC, respectively, with the circle. The tangents at P and Q divide the base in the ratios $k : l$ and $m : n$, respectively. Construct the triangle ABC.

No solutions received. The Editor submits the following:

For the problem to have a unique solution, P and Q must be given.

Assume the triangle constructed. Let M and N be points of intersection with BC of tangents at P and Q, respectively, and let O be the point of intersection of PM and PN. BM : MC = $k : l$, and BN : NC = $m : n$; PBM and NQC are right triangles; $\angle POQ = 180° - \angle A$.

We begin by constructing a figure A′P′B′M′O′N′C′Q′A′ similar to the one desired.

On a given line B′C′ determine points M′ and N′ so that B′M′ : M′C′ = $k : l$ and B′N′ : N′C′ = $m : n$. Describe semicircles (on same side of M′N′) on B′M′ and N′C′ as diameters. If M′ lies between B′ and N′ the tangents at P′ and Q′ intersect M′N′ before intersecting each other. In this case draw an arc on M′N′ (on side of M′N′ opposite the semicircles) in which would be inscribed the angle $180° - \angle A$. P′ will lie on semicircle B′M′, Q′ on N′C′, and O′ on arc M′N′. Our problem, then, is to determine two equal lines O′P′ and O′Q′ so that M′ lies on O′P′ and N′ on O′Q′. Assuming this done, according to the conditions of the problem we have the following relations:

Choosing, for brevity, the notation $\alpha = \angle P'M'B'$, $\beta = \angle Q'N'C'$ (then $\alpha+\beta = \angle A$, given); $\rho = B'M'/2$, $r = N'C'/2$, $c = Q'N'$, $\gamma = P'M'$, $t = O'N'$, $\tau = P'M'$, $d = M'N'$, δ = projection of t on M′N′; then

$$\gamma+\tau = c+t, \tag{1}$$

$$t/2r = \delta/c, \tag{2}$$

$$\tau/2\rho = (d-\delta)/\gamma. \tag{3}$$

(By similar triangles)

$$\tau/\sin\beta = t/\sin\alpha = d/\sin A, \quad (\sin A = \sin[180° - (\alpha+\beta)] \tag{4}$$

$$\tau\cos\alpha + t\cos\beta = d, \tag{5}$$

$$\cos\alpha = \gamma/2\rho, \quad \cos\beta = c/2r. \tag{6}$$

We use the last five equations to express γ, τ and c in terms of t. Since from (4),

$$\tau\sin\alpha - t\sin\beta = 0, \tag{7}$$

if we multiply (7) by $\sin\alpha$, (5) by $\cos\alpha$, add, reduce by addition formula for cosines, substitute values in (6) and transpose, we have

$$\tau = \gamma d/2\rho + t\cos A.$$

From (6) and (4),

$$\gamma = 2\rho\cos\alpha = 2\rho\frac{\sqrt{d^2-t^2\sin^2 A}}{d^2} = 2\rho/d\sqrt{d^2-t^2\sin^2 A} \tag{8}$$

Hence

$$\tau = \sqrt{d^2-t^2\sin^2 A}+t\cos A \tag{9}$$

Eliminating δ from (2) and (3),

$$c = (2\rho r d - \tau\gamma r)/\rho t.$$

Substituting now the values of γ and τ from (8) and (9),

$$c = 2r/d(t\sin^2 A - \cos A\sqrt{d^2-t^2\sin^2 A}). \tag{10}$$

Substituting the values of (8), (9), (10) in (1), we obtain, after some reduction,

$$t = \frac{2\rho+2r\cos A+d}{\sqrt{\left(\frac{2\rho+2r\cos A+d}{d}\right)^2\sin^2 A+\left(\frac{2r\sin^2 A-d\cos A+d}{d}\right)^2}}$$

From this form t may be constructed although the work involves thirteen separate constructions by compass and ruler such as fourth proportional, sum of squares, finding a linear ratio equal to a ratio of squares, and making ratios to replace sinA and cosA.

With t as a radius and N′ as center describe arc intersecting arc M′N′ at O′. O′P′ and O′Q′ will be the equal tangents to the circle A′ at the points P′ and Q′, respectively, and will determine the circle. If R′ be

the radius of this circle and R of the given circle, then the fourth proportional to R′,R and A′B′ will be AB, the side of the desired triangle. AC and BC may be constructed in a similar manner.

If N′ lies between B′ and M′ the arc M′N′ would be described on the same side of B′C′ as the semicircles and a slight change of notation would be necessary to carry through the same argument for this case as for the preceding.

The Editor recognizes that this is a devious method and will welcome a simple one.

Late Solutions.

566. M. B. Messinger, Mehta Kanhyalal.

PROBLEMS FOR SOLUTION.

Algebra.

586. *Proposed by Philomathe, Montreal, Can.*

Solve, by Elementary Algebra:

$$2x^2+\sqrt{x^2+9} = x^4-9.$$

587. *Proposed by W. T. Harlow, Portland, Ore.*

A merchant takes $1,000 every year out of his income for personal expenses. Nevertheless his capital increases every year by a third of what remains. At the end of three years it is doubled. How much had he at first? (From Chrystal's *Algebra.*)

588. *Proposed by Daniel Kreth, Wellman, Ia.*

Given:

$$y+\sqrt{y/x} = 42/x \qquad (1)$$
$$x^2/3+x/2\sqrt{y} = 54/y \qquad (2)$$

Find x and y.

589. *Proposed by N. P. Pandya, Amreli, Kathiawar, India.*

AB is a chord of a circle. Find a point C on AB, such that if tangents CD and CE be drawn to the circle, and if EF, parallel to AD, cuts CD in F, CD may be bisected at F.

590. *Proposed by Daniel Kreth, Wellman, Ia.*

AB is a chord in a given circle, bisected in C. DE and FG are any two chords intersecting each other in C; FE intersects AB in H, and DG intersects AB in K. Prove that CH = CK. Geometrical and trigonometrical solutions are desired.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 *Wilbur Ave., S. E., Cleveland, Ohio.*

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

War Questions on Science.

310. What questions on science, new and old, has the war brought to our attention?

It will be most timely to give general circulation to such questions as

have come to your attention, especially those which have introduced interesting discussions into your classes. Mail them to the Editor now.

Would you guess from current questions in science examinations that the past two years represent the most stupendous scientific development ever known?

The following list of questions speaks for itself:

College Entrance Examination Board.

Comprehensive Examination in Physics, Friday, June 21, 1918.

A teacher's certificate covering the laboratory instruction must be presented as a part of the examination unless the laboratory notebook is to be presented at a laboratory examination.

Answer ten numbered questions, distributed as follows: three from Group I, two from Group II, two from Group IV, two from Group V, and one of the remaining questions.

The number in parentheses before each question indicates the number of credits assigned to it.

Show clearly the method by which you obtained your answers to problems and state the units used in each case.

Attach to the answer, in each case, the number and letter used in the printed paper.

Group I.

1. A wooden cube 5 cm. on an edge weighs 100 g. (*a*) (3) What is the density of the cube? (*b*) (3) What force would be required to hold the cube submerged in a liquid having a density of 1.5 g. per cu. cm.? (*c*) (4) How much of its volume would protrude above the surface if the cube were floated in a liquid having a density of 1.2 g. per cu. cm.?

2. (*a*) (3) Define work; mechanical advantage of a machine; efficiency of a machine. (*b*) (7) Two men raise a weight by means of a jackscrew. They push with a force of 100 lbs. each, at opposite ends of a bar 5 ft. long that passes through a hole at the top of the screw. If the pitch of the screw is 1-2 inch and the efficiency of the machine is 30 per cent, how great is the weight?

3. An engine operates a pump which raises water to a height of 50 ft. at the rate of 1,000 gal. per min. (One gallon of water weighs 8.4 lbs.) (*a*) (3) How much work is done upon the water per second? (*b*) (7) If the efficiency of the pump is 90 per cent, how many horse-power is the engine developing?

4. A constant force acting on a mass of 40 grams for 5 seconds changes its velocity from 60 cm. per second to 100 cm. per second. What is: (*a*) (2) the acceleration? (*b*) (2) the magnitude of the force? (*c*) (2) the total distance covered in the five seconds? (*d*) (2) the final momentum? (*e*) (2) the kinetic energy at the end of the first two seconds?

5. (*a*) (8) A tank having a volume of 12 cu. ft. contains air under a pressure of 30 lbs. per sq. in. On connecting the tank to an exhausted receptacle the air pressure is reduced to 10 lbs. per sq. in. Find the volume of the receptacle. (*b*) (2) Describe two phenomena that are caused by surface tension.

Group II.

6. (*a*) (2) Define coefficient of linear expansion. (*b*) (8) Describe an experimental method of measuring the coefficient of linear expansion of a solid, describing the apparatus used, the measurements made, and the way in which these measurements are used to compute the coefficient.

7. (*a*) (6) A balloon is filled on a cool night with 20,000 cu. ft. of gas at a temperature of 7° C. under a pressure of 15 lbs. per sq. in. In the sunshine of the day the gas becomes warmed. At what temperature will the pressure reach 16 lbs. per sq. in.? Assume that the gas bag does not stretch and that no gas escapes. (*b*) (2) Express 9° C. on the Fahrenheit scale. (*c*) (2) Compare the advantages of mercury and of air as thermometric substances.

8. (*a*) (2) Name and define a unit quantity of heat. (*b*) (8) A copper calorimeter of mass 210 g. contains 85 g. of water and 100 g. of lead shot at 15° C. How much boiling water must be added to raise the temperature

of the calorimeter and contents to 25° C.? (Sp. ht. of copper = 0.095; of lead = 0.032.)

GROUP III.

9. (*a*) (2) What conditions are necessary for the formation of an echo? (*b*) (2) What is the physical difference between a noise and a musical sound? (*c*) (2) Why is thunder usually heard some time after a lightning flash is seen? (*d*) (2) Upon what does the loudness of sound depend? (*e*) (2) Upon what does the pitch of a sound depend?

GROUP IV.

10. (*a*) (3) A more sharply defined shadow is cast by an opaque body when the source of light is an arc lamp than when it is a gas jet. Explain by the aid of diagrams. (*b*) (3) What should be the brightness of a single light in the ceiling 10 ft. from a book to give the same illumination as two candles placed one foot from the book?

(*c*) (4) Explain what is meant by saying that the index of refraction of water is 4/3. Make a careful, fully labeled diagram showing the passage of a ray of light obliquely from air into water.

11. (*a*) (2) Define principal focus; conjugate foci. A moving-picture machine is to be designed to project the picture on the film [illegible] on a screen 60 ft. from the film. If the image on the screen is to be [illegible] times the linear dimensions of the picture on the film: (*b*) (2) How far from the film must the projection lens be placed? (*c*) (4) What must be the focal length of the lens? (*d*) (2) How many times as intense will be the light passing through the film as that falling on the screen?

12. (*a*) (4) Make a diagram to show the dispersion of a narrow beam of sunlight by a triangular glass prism. (*b*) (4) What is the explanation of refraction? of dispersion? (*c*) (2) Explain carefully why the same blue cloth may seem to be of a different color when viewed by gaslight and by sunlight.

GROUP V.

13. (*a*) (2) What type of cell is best adapted to the ringing of electric bells? Why? (*b*) (2) What is meant by the term local action as applied to voltaic cells? (*c*) (2) How may local action be reduced? (*d*) (2) What is meant by polarization of cells? (*e*) (2) How may polarization be reduced?

14. Two resistance coils of 10 and 30 ohms joined in parallel are connected in series with a key, an ammeter of negligible resistance, and a battery whose electromotive force is 21 volts and whose internal resistance is 3 ohms. A voltmeter of high resistance is connected in parallel with the battery. (*a*) (2) Draw a diagram of the connections. (*b*) (2) What will be the ammeter and voltmeter readings when the key is open? (*c*) (6) What will the readings be when the key is closed?

15. (10) Describe the construction and operation of two of the following: electric bell; telegraph key and sounder; telephone receiver. Illustrate by carefully drawn diagrams.

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly, for September; *27 King Street, Oberlin, Ohio:* "Definitions of the Discriminant of a Rational Integral Function of One Variable," G. A. Miller; "What is the Origin of the Name 'Rolle's Curve'?" Florian Cajori; "The Mathematics of Aerodynamics," E. B. Wilson.

American Naturalist, for August-September; *Garrison, N. Y.; $4.00 per year, 80 cents a copy:* "The Relation Between Color and Other Characters in Certain Avena Crosses," H. H. Love and W. T. Craig; "Opisthotonos and Allied Phenomena Among Fossil Vertebrates," Roy L. Moodie; "Cancer's Place in General Biology," W. C. MacCarty; "A Survey of the Hawaiian Coral Reefs," Vaughn MacCaughey.

Astrophysical Journal, for September; *University of Chicago Press; $5.00 per year, 65 cents a copy:* "The Visibility of Radiation," Edward

P. Hyde, W. E. Forsythe, and F. E. Cody; "Studies Based on the Colors and Magnitudes in Stellar Clusters," Harlow Shapley; "The Absorption of Near Infra-Red Radiation by Water-Vapor," W. W. Sleator.

Auk, for October; *Cambridge, Mass.;* $3.00 *per year,* 75 *cents a copy:* "The Nesting Grounds and Nesting Habits of the Spoon-billed Sandpiper," Joseph Dixon; "A Winter Crow Roost," Charles W. Townsend; "The Pterylosis of the Wild Pigeon," Hubert L. Clark; "Sexual Selection and Bird Song," Chauncey J. Hawkins.

Blast Furnace and Steel Plant, for October; *Pittsburgh, Pa.,* $1.00 *per year;* 15 *cents a copy:* "Cement Gun Used in Repairing Pit Stacks, Characteristic of Automatic Engine Stops," Walter Greenwood; "Remote Controlled Sub-Station Described," W. T. Snyder; "Standardizing Large Rolling-Mill Motors," K. Pouly; "Electrically Driven Mills at Bethlehem," J. T. Sturtevant.

Condor, for September-October; *Hollywood, Calif.;* $1.75 *per year,* 30 *cents a copy:* "Notes on the Nesting of the Mountain Plover," W. C. Bradbury; "Evidence That Many Birds Remain Mated for Life," F. C. Willard; "Some Ocean Birds from Off the Coast of Washington and Vancouver Island," Stanton Warburton.

Geographical Review, for October; *Broadway at 156th Street, New York City;* $5.00 *per year,* 50 *cents a copy:* "The Geographical Barriers to the Distribution of Big Game Animals in Africa," Edmund Heller. (1 map, 14 photos); "The Outline of New Zealand," C. A. Cotton. (1 map, 7 diagrs., 11 photos); "The Slavs of Southern Hungary," B. C. Wallis. (3 insert maps in color, 1 text map, 1 diagr.); "The Activities of the Canadian Arctic Expedition from October, 1916, to April, 1918," Vilhjalmur Stefansson. (1 insert map.)

Journal of Geology, for September-October; *University of Chicago Press;* $4.00 *per year,* 65 *cents a copy:* "Permo-Carboniferous Conditions versus Permo-Carboniferous Time," E. C. Case; "Notes on the Geology of Eastern Guatemala and Northwestern Spanish Honduras," Sidney Powers; "Loess-Depositing Winds in Louisiana," E. V. Emerson; "Description of Some New Species of Devonian Fossils," Clinton R. Stouffer.

National Geographic Magazine, for August; $2.50 *per year; Washington, D. C.:* "Bringing the World to Our Foreign-Language Soldiers," with 4 illustrations, Christina Krysto; "Recent Observations in Albania," with 22 illustrations, Brig. Gen. George P. Scriven; "The Ukraine, Past and Present," with 14 illustrations, Nevin O. Winter; "The Acorn, a Possibly Neglected Source of Food," with 8 illustrations, C. Hart Merriam; "Our Littlest Ally," with 16 illustrations, Alice Rohe.

Photo-Era, for October; $2.00 *per year,* 20 *cents a copy; Boston, Mass.:* "Craft and Art in Amateur Photography," Edouard C. Kopp; "Proe and Kahn on Soft-Focus Lenses," August Krug; "Pictures that Appeal," H. B. Rudolph; "Pictorial Photography as I See It (In Three Parts—Part III)," C. W. Christiansen; "A New Plan for Salon-Hangings," Sigismund Blumann; "Trial-Exposures and Economy," British Journal.

Physical Review, for November; $6.00 *per year,* 60 *cents a copy, Ithaca, N. Y.:* "Note on the Reversal of the Corbino Effect in Iron," Alpheus W. Smith; "The Relation between Certain Galvanomagnetic Phenomena," C. W. Heaps; "The Photoluminescence and Kathodo-Luminescence of Calcite," E. L. Nichols, H. L. Howes and D. T. Wilber; "The Evaporation of Small Spheres," Irving Langmuir; "The Motion of an Electrical Doublet," Leigh Page; "Law of Motion of a Droplet Moving with Variable Velocity in Air," Raymond B. Abbott; "The Specific Heat of Tungsten at Incandescent Temperatures," Paul F. Gaehr.

PERSONALS.

Mr. James H. Armstrong, for many years principal of one of Chicago's largest high schools, the Englewood, has recently been promoted to Assistant Superintendent in charge of Chicago's high schools. This is a most important position, one which has for many years been vacant to the great detriment of the high schools. No one in Chicago is better qualified in every particular to fill this most important position than Mr. Armstrong. This journal predicts a new era and all-round improvement in these schools under his management.

Mr. Franklin T. Jones, editor of Science Questions' Department in this journal, lately with the Glidden Paint and Varnish Company of Cleveland, has after many years again connected himself with the Warner and Swasey Company of Cleveland. Among other matters Mr. Jones will have charge of the development of an apprentice school into a junior engineering college.

Professor M. E. Grober has been elected to the chair of mathematics in Heidelberg University, Tiffin, Ohio.

Dr. W. O. Mendenhall, who has been professor of mathematics in Earlham College, has been made president of Friends' University, Wichita, Kansas.

Dr. E. L. Packard of the geology department at the Agricultural College of Mississippi has accepted a position in his chosen subject at the University of Oregon.

Dean Albert R. Mann, of the College of Agriculture at Cornell University, has been appointed by Governor Whitman a member of the state food commission.

Dr. Veranus A. Moore, head of the New York State Veterinary College at Cornell University, was elected president of the American Veterinary Medical Association at the Philadelphia meeting.

Professor George F. Freeman, of the College of Agriculture in the University of Arizona, has moved to Cairo, Egypt, where he will be connected with the Société Sultamenne de Agricultur.

Professor O. P. Jenkins, of the geology department of the State College of Washington, has been made geologist to the Arizona State Bureau of Mines, Tucson.

Professor J. W. Young, of Dartmouth College, has been made director of mathematics instruction in war work, given under the management of the Y. M. C. A.

Professor Edwin E. Hill succeeds to the position of director of the Jefferson Physical Laboratory of Harvard University, due to the retirement of Professor W. C. Sabine.

Dr. William P. Brooks has resigned from the position of director of the Massachusetts Agricultural Experiment Station, a position which he has held for nearly thirty years.

A SIMPLE "FALL" APPARATUS.

BY A. H. COOPER,

Grove Park School, Wrexham, Eng.

The need for a simple and direct method of demonstrating to junior students the fact that a freely falling body moves with a constant acceleration, has frequently been felt by teachers of physics.

The apparatus described below has been in use by the writer for some five or six years, and has been of great service in making clear the laws of falling bodies to elementary students. It possesses the advantages that the whole apparatus is simple; an experiment is quickly performed;

the motion of the falling body is traced absolutely from rest; from a single experiment it is easy to show with considerable accuracy that (a) the velocity is proportional to the time; (b) the distance fallen is proportional to the time squared; (c) the acceleration is constant, each of these being shown directly and independently; no assumption is made beyond that of the constancy of period of a vibrating spring; if the period of the spring is known, the value of g can be obtained with fair accuracy.

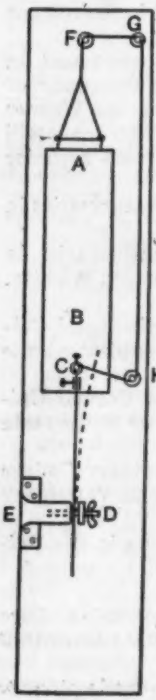


FIG. 1.

The essentials of the apparatus are shown in the diagram (Figure 1). The "falling plate," AB, consists of a board, 2 ft. by 4 in. by ¾ in. It is supported by a thread, with a loop passing under two screw-hooks in the upper edge of the board. The thread passes over long smooth nails at F, G, H, and terminates in another loop, which is placed over the brush-holder C, carried by the spring CD. On gently releasing the board, its weight, acting along the thread, deflects the spring slightly towards H. The spring is held in a clamp ED, screwed to the vertical back-board, and carries a small brush. The spring can be pressed over a little towards H, to give greater amplitude. A sheet of paper is previously pinned to the face of AB; the brush is now inked, and the thread burnt by a taper applied between G and H. Board and spring start moving at the same instant, and a curve similar to the one shown in Figure 2 is obtained. A frequency of from 15 to 20 is suitable for the spring, and this can be readily adjusted by means of the clamp.

The displacement, velocity, and acceleration of the falling body can now be obtained from the curve, for any stage of the motion; calling the period of the spring, for convenience, one second, the displacements after 1, 2, etc., seconds are given by AB, AC, AD, etc.; the corresponding velocities, however, are not given by AB, BC, etc., but by GH, HK, etc., since GH represents the distance traversed in one second, at the middle of which the body was at B, i. e., had been falling for one second; similarly, the velocity after two seconds is given by HK, and so on. The accelerations are given by GH, HK—GH, etc.

The following results are taken from an actual experiment:

t	s	v	a	s/t^2	v/t
1	1.6	3.35	3.35	1.60	3.35
2	6.6	6.7	3.35	1.65	3.35
3	14.9	10.1	3.40	1.66	3.37
4	26.6	13.4	3.30	1.66	3.35
5	41.8	16.85	3.45	1.67	3.37

It will be seen that these results show clearly that the acceleration is constant, that s is proportional to t^2, and that v is proportional to t, the two latter facts, though not independent of the first, being more usefully illustrated directly, for junior students, than deduced from the first, or *vice versâ*.

The value of g can also now be at once found, if the period of the spring be known; a frequency of from 15 to 20 is suitable, giving, on a two-foot board, curves easily measured with sufficient accuracy with

a metre-scale, reading all lengths to the nearest millimetre, or at most, half-millimetre, as in the example given. In this case, the spring had a frequency of 17.14, and using the value of the acceleration obtained from the greatest displacement (41.8 cm., $t = 5$), we have

$$a = \frac{2s}{t^2} = \frac{83.6}{25} \text{ cm. per "}t\text{" per "}t\text{,"}$$

where t is the period of the spring, or

$$g = \frac{83.6}{25} \times (17.14)^2 \text{ cm. per sec. per sec.}$$

$$= 982.3 \text{ cm. per sec. per sec.}$$

In the example quoted, the frequency was measured by means of an auxiliary spring, fitted with inked brush also; it was adjusted so as to vi-

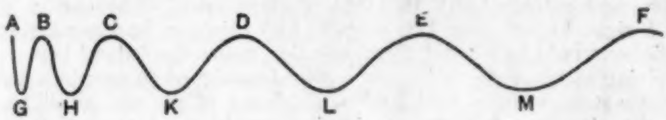


Fig. 2.

brate sufficiently slowly to admit of counting and timing with a stop-watch; its period was then compared with that of the spring in use by allowing the falling plate to move slowly down, both brushes making a trace on it. A comparison of the curves gave the ratio of the periods.

Various further illustrations of uniformly accelerated motion can be taken from the results; the equations $s = \frac{1}{2} at^2$, $v = at$, $v^2 = 2as$, for motion from rest, are at once verified, while by starting measurements from various points on the curve, the more general equations, $s = ut + \frac{1}{2}at^2$, $v = u + at$, $v^2 = u^2 + 2as$, can be readily shown to be applicable.

It is perhaps worthy of mention that the apparatus was worked out, and in use, before the Fletcher trolley was brought to the writer's notice. The trolley has added immensely to the science teacher's resources in the way of experimental illustration of motion, and the apparatus here described can only claim to deal with one case, but that case is of such importance that a simple method of demonstrating its features may prove of use.—[*School World.*

ILLEGIBLE SIGNATURES.

"Can you decipher that written signature?" says the employer to his stenographer, handing her a letter with a signature that he had tried hard, but in vain, to read. The employee makes a protracted attempt, but is unsuccessful. The letter with the illegible signature goes the rounds of the office, but with no favorable result. The letter is an important one, and cannot be answered until the sender has sent several letters of inquiry, in the last one of which his signature has been written fairly legibly. Much valuable time is thus needlessly wasted.

To obviate any similar trouble, Rear Admiral Spencer S. Wood, commandant of the First Naval District, has issued an order that, hereafter, when any officer has to sign his name to an official document, he must first typewrite it and then write it underneath in his own hand.

We commend this practice to those who habitually write their names in characteristic but illegible fashion. An excellent substitute might be for the stenographer to typewrite, in conjunction with her own initials, the full name of the writer.—[Photo-Era.

THE AMERICAN SOLDIER.

By Antoinette Funk.

When a man is selected for military service the immediate anxiety, the immediate concern, is his destination, his housing, feeding, clothing, and health.

The new soldier is under the direction of the Provost Marshal General's department from the time he is accepted until he takes train for the camp he is assigned to. Then the transportation department takes him in charge. If his journey is a long one he travels by Pullman or tourist sleeper. Meals are provided to him along the way, at a maximum cost of sixty cents by the Government.

Under a recent ruling the selected man is immediately given an arm-band. This is an insignia of military standing and is worn until he is fitted with a uniform. This arm-band carries the same authority, protection, and responsibility that the uniform does. The enemy would have a right to fire upon him or take him prisoner, and anyone selling him liquor would be subject to prosecution under the federal law.

Arriving at his cantonment the soldier is assigned to quarters, usually in a two-story wooden building, with plenty of air and sunlight, and with the cleanest of floors—floors that would meet the old-time test "clean enough to eat from." He sleeps in a well-ventilated room with other soldiers, but not too many, the number being regulated by the cubic feet of air space in the chamber. The army bed is an extra width cot with good steel springs and bedding suited to the weather and climate; never less than two blankets are assigned him, all-wool blankets, khaki color. Sometimes he gets three and two thick comforters more if weather demands.

Lavatories are located at the rear of these quarters, with water pressure and fixtures of a design similar to that used in the best hotels in the country, and for every company unit there are from four to six shower baths. Cleanliness of person and surroundings are absolute requirements of the United States Army. Every possible precaution is taken by the sanitary corps to insure that the camp conditions are 100 per cent sanitary.

Drainage is installed along strictly scientific lines, and the most scientific disposition is made of all camp sewage. During previous wars more men have died from preventable disease than from bullet wounds. During the Civil War soldiers perished by thousands from typhoid, camp fever, dysentery, and kindred diseases resulting from unsanitary conditions about the camp. Those days are gone. Surgeon General Gorgas, who made the building of the Panama Canal possible by draining the Canal Zone and fitting it for human habitation, is in charge of the army sanitation.

As soon as the soldier is assigned to quarters he is given the most searching physical examination. All scientific medical tests are applied to detect disease. For instance, if there are indications of tubercular infection the patient is put under observation that there may be no mistake in the diagnosis. If there is incipient trouble he is sent to one of the army sanitariums and restored to health. If his case is advanced he is relieved from military service or exempted until physically fit.

Besides the examining surgeon there is the dentist. Teeth are put in good condition here, and there are dentists overseas to keep them in good condition. Also there is an orthopedic surgeon to examine the soldier's feet. It has been said that during past wars there were more desertions from foot trouble than all other causes combined. The

attention given to the selection of shoes for the soldiers in the American army is a sidelight on the care we give our fighting men.

When a soldier gets his first pair of shoes he gets a pair that fit his feet. No account is taken of the size he wore before. His feet are placed in a cunningly devised form where the length and width are exactly determined. He bears his weight on this little machine and an officer and a noncommissioned officer take the size record of both feet, his name, company, and regiment. Then he puts on a pair of shoes of the size called for. But that doesn't end it. There is a further device that checks on the measuring machine and catches any human error in recording. This is put inside his shoe and he runs down an incline of thirty degrees, striking his heels on the cleats nailed to it. If this little machine does not make itself felt and the shoe after examination by an officer is found to be satisfactory, the man is fitted and his size is added to his service record.

Our soldiers are provided with clean socks, and at the end of long marches the feet are carefully inspected by the surgeon in charge.

No army in the world has ever attained such a health record as ours, the death rate being eight out of every thousand, here and abroad. This would be even lower but for the large number of men who come down with diseases to which they were exposed before leaving home.

The average gain in weight of the American soldiers since entering the service is twelve pounds per man.

IRON ORE AND PIG IRON IN 1917.

Statistics compiled under the direction of E. F. Burchard of the United States Geological Survey, Department of the Interior, show that the iron ore mined in the United States in 1917 reached a total of 75,288,851 gross tons, and exceeded the former record output of 1916 by 121,179 tons. The shipments from the mines in 1917 were 75,573,181 gross tons, valued at $238,260,333, a decrease in quantity of 2,297,372 tons, or 2.95 per cent, and an increase in value of $56,358,056, or 30.98 per cent, as compared with shipments in 1916.

Iron ore was mined in twenty-five states in 1917 and twenty-four in 1916. California, Montana, and Nevada produced iron ore for metallurgic flux only; part of the output of Colorado, New Mexico, and Utah was used for smelter flux and part for pig iron and ferro-alloys; the remaining states produced iron ore mainly for use in blast furnaces, except small quantities used for paint from Michigan, New York, Wisconsin, and Georgia. The ore output of Minnesota, Michigan, and Alabama, the states which have for many years produced the largest quantities of iron ore, was respectively 44,595,232 tons, 17,868,601 tons, and 7,037,707 tons, and was close to that of 1916, Minnesota having shown an increase of .02 per cent, Michigan a decrease of 1.1 per cent, and Alabama an increase of 4.3 per cent. More than 1,000,000 tons of ore each was produced also by New York and Wisconsin in 1917.

The principal iron-mining districts in the United States, except the Adirondack and Birmingham districts, are interstate, so that statistics of production by districts are also of interest and importance. The Lake Superior district mined 63,481,321 tons of ore in 1917, or nearly 85 per cent of the total, and the Birmingham district mined 6,187,073 tons, or more than 8 per cent. There were small decreases in output from the Lake Superior, Chattanooga, and New York-New Jersey districts, and increases in the Birmingham and Adirondack districts, the production from the Adirondack district having again exceeded 1,000,000 tons.

In the Lake Superior iron-ore ranges the Mesabi mined 41,127,323 tons, a decrease of about 5 per cent from the output of 1916; the Gogebic mined 7,881,232 tons, an increase of 2.26 per cent; the Menominee 6,366,483 tons, a decrease of 4.26 per cent; the Marquette 4,638,374 tons, a decrease of 3.22 per cent; the Vermilion 1,481,301 tons, a decrease of 13.09 per cent, and the Cuyuna 1,986,608 tons, an increase of 27.7 per cent, as compared with 1916.

The imports of iron ore in 1917, according to the records of the Bureau of Foreign and Domestic Commerce, were 971,663 gross tons, compared with 1,325,736 tons in 1916.

SAMUEL W. WILLISTON.

The unexpected death at the Presbyterian Hospital in Chicago, after a surgical operation for cancer, of Samuel Wendell Williston, Professor of Paleontology in the University of Chicago, brought to the scientific world the loss of one of its ablest and most versatile members. As a paleontologist he was a foremost authority, and among the books that brought him greatest fame were *American Permian Vertebrates* and *Water Reptiles of the Past and Present.* He was a voluminous contributor also to the literature of entomology, zoology, sanitation, and comparative anatomy.

For many years Professor Williston was connected with Yale University and served as the health officer of New Haven. Later he became professor of historical geology and anatomy and dean of the medical school at the University of Kansas. For the last sixteen years he was professor of paleontology at the University of Chicago, where the results of his research attracted wide attention among scientific men.

Dr. Williston had many honors conferred upon him by scientific societies and institutions, among them being membership in the National Academy of Sciences, the presidency of the honorary scientific society of Sigma Xi, and the presidency of the Society of Vertebrate Paleontology. His reputation abroad was recognized by his appointment to represent the United States Government in the International Congress of Scientists at Monaco in 1913.

ESCAPED OFFICERS SAY AUSTRIANS AS A PEOPLE DETEST THE GERMANS.

Three Italian officers who succeeded in escaping from Austrian concentration camps gave interviews on the conditions in the interior of Austria when they arrived in Italy. They said the middle class and those who do not own real estate suffer extreme privation, although the farmers and workmen live far better.

The prisons and concentration camps are charnels, owing to the lack of food, of clothes, and of medicines.

All of the officers agreed in saying that the Austrians detest the Germans.

Whenever Germans enter a cafe or other public resort, the Austrians who happen to be within leave the place forthwith. They are all tired of the war and the news from the front finds the public altogether indifferent.

The food supply outlook for next winter, owing to the shortage of the harvest, is discouraging. During their long stay and their journey through Austria the only thing the people discussed with any interest was how to get food.

They added that many officers in the Austrian army refuse to salute the Germans.

HOLD YOUR LIBERTY BONDS.

The United States Government is resolved to do its best to restore every wounded American soldier and sailor to health, strength, and self-supporting activity.

Every Liberty Bond holder who holds his bond is keeping up a part of this great work of restoring to health, strength, and usefulness the men who have suffered for their country.

Until his discharge from the hospital all the medical and surgical treatment necessary to restore him to health is under the jurisdiction of the military or naval authorities, according to the branch of the service he is in. The vocational training, the reeducation and rehabilitation necessary to restore him to self-supporting activity is under the jurisdiction of the Federal Board for Vocational Education.

If he needs an artificial limb or mechanical appliance the Government will supply it free, will keep it in repair, and renew it when necessary. If after his discharge he again needs medical treatment on account of his disability, the Government will supply it free. While he is in the hospital and while in training afterwards the soldier or sailor will receive compensation as if in service and his family or dependents will receive their allotment.

A wounded soldier or sailor, although his disability does not prevent him from returning to employment without training, can take a course of vocational training free of cost and the compensation provided by the war-risk insurance act will be paid to him and the training will be free, but no allotment will be paid to his family.

* * * * * * *

Hold Your Liberty Bonds.

Don't surrender your Liberty Bond conditionally or unconditionally. Hold fast to that which is good. Keep your Liberty Bonds.

NUMERICAL PROBLEMS IN CHEMISTRY.

By Jessie Caplin,
West High School, Minneapolis, Minn.

I require that stochio-chemical problems shall be solved in this way:

1. Equation.
2. Known and unknown quantity.
3. Combining weights or volumes (two only).
4. Proportion.

I try to impress the fact that these are types of real problems. After working on a few in the text, I require that pupils shall state and solve their own. Work is assigned like this:

Using any (given) equation,

1. State and solve a problem involving weights:
(a) Known and unknown in first member.
(b) Known and unknown in second member.
(c) Known in first, unknown in second.
(d) Known in second, unknown in first.
2. State and solve a problem involving weight and volume:
(a) Volume unknown.
(b) Volume known.
3. State and solve a problem involving volumes only.
4. Similarly for Boyle's and Charles's Law:

I teach the use of logarithms and encourage their use in the solution of Boyle's and Charles's Law problems. In the other kinds of problems, I encourage the children to estimate the answer.

QUICKSILVER PRODUCTION IN FIRST HALF OF 1918.

The production of quicksilver in the United States during the first half of 1918 was 17,576 flasks, according to F. L. Ransome, of the United States Geological Survey, Department of the Interior. The total production in 1917 was 35,954 flasks. With the enlargement of our Army the demand for quicksilver is likely to be considerably greater in 1919 than in 1918, and the perfection of satisfactory detonators for high explosives that shall contain little or no mercury is one of the urgent problems of chemistry as applied to war.

The decline in production during the first half of 1918 was due chiefly to the shortage and the increased cost of labor and to the exhaustion or depletion of known ore bodies under the stimulus of high prices for the metal. The practice at some of the larger mines has been to devote nearly all energy to getting out ore and to postpone the underground exploration and development that are necessary to insure long-continued steady production.

Quicksilver mining is full of uncertainties, and capitalists are slow to invest extensively in an undertaking whose future can be so little foreseen. There is opportunity here for patriotism to cast the deciding vote where the cold doctrine of chances might turn the investor to industries offering greater assurance of reward.

One of the notable achievements in the industry during the year has been the successful adaptation of the rotary cement kiln to quicksilver metallurgy. Eight of these furnaces are now or will soon be in operation in California, and they are expected to make an increase in production that may more than offset the falling off during the first half of the year.

ITALIAN DIRIGIBLES SHOW 109 ACTIONS WITH ENEMY IN ONE YEAR.

The Secolo has received word from a correspondent at the front that four Italian dirigibles were in 109 actions with the enemy between August last year and September 1, this year, and threw several tons of explosives on enemy works and objectives.

Three dirigibles were in twenty-five actions last July and in thirty-three in August. Italian airships altogether navigated 290 hours, covering 18,500 kilometers in their courses and dropping forty tons of explosives.

The record for the heaviest cargo dropped is held by the dirigible commanded by a captain with a marvelous service record. He has fought in forty-four actions. In August he effected seven bombardments, going on one occasion over the fields of Feltre and dropping 7,200 kilos of bombs.

Next is an aeroplane commanded by a valiant major who is the ace of our flyers. He has made forty-nine flights and accomplished eight bombardments. Among his feats was the passage of the Alps through the Trentino, surmounting Carre peak, 3,465 feet high, the highest of the Adamello.

The other two dirigibles were commanded respectively by a captain with twenty-one actions to his record and by a captain with twenty-five. One achieved four bombardments and the other three.

BOOKS RECEIVED.

General Science and the Economics of Daily Life, by Herbert Brownell, Teachers' College, University of Nebraska. Pages xi+383. 14x20 cm. Cloth. 1918. $1.00 net. P. Blakiston's Son & Co., Philadelphia, Pa.

Starved Rock State Park and its Environs, by Carl O. Sauer, Gilbert H. Cady and Henry C. Cowles, the University of Chicago. Pages x+148. 40 figures. 2 maps. 17x24.5 cm. Cloth, 1918. $2.00 net. The University of Chicago Press.

Surgical Nursing in War, by Elizabeth R. Bundy, Woman's Hospital, Philadelphia. Pages vi+184. 12x18.5 cm. Cloth, 1918. 75 cents. P. Blakiston's Son & Co., Philadelphia, Pa.

Elementary General Science, by Daniel R. Hodgdon, State Normal School, Newark, N. J. Pages xxii+553. 15x20.5 cm. Cloth. 1918. $1.50. Hinds, Hayden and Eldredge, Chicago.

United States Official Postal Guide. 830 pages. 17x25 cm. Cloth. 1918. $1.00. Post Office Department, Washington, D. C.

The Waterbugs and Their Cousins, by Charles D. Lewis, Berea College, Normal School. Pages xii+172. 13.5x19.5 cm. Cloth. 1918. $1.75. J. B. Lippincott Company, Philadelphia.

Four-Place Logarithmic and Trigonometric Tables, together with Interest Tables, by Louis C. Karpinski, University of Michigan. 30 pages. 13x19 cm. Paper. 1918. 30 cents. George Wahr, Publisher, Ann Arbor, Mich.

A Study of Engineering Education, by Charles Riborg Mann, The Carnegie Foundation for the Advancement of Teaching. Pages xi+139. 18.5x25 cm. Paper. 1918. The Foundation, 576 Fifth Avenue, New York City.

BOOK REVIEW.

Progressive Chemistry, a Laboratory Manual, by P. A. Davis, North High, Louis G. Cook, East High, B. T. Emerson, Central High, Jessie F. Caplin, West High, and Kate McDermid, South High, Minneapolis, Minn. 3d edition, revised. Pp. .... 45 exps. No diagrams. Pasteboard back, perforated and punched. 1918. Printed for the authors. Mail address: Kate McDermid, South High, Minneapolis.

The particular virtues claimed for this laboratory manual by the authors are: (1) no diagrams, so apparatus can be used as supplies permit; (2) test tubes are used in place of flasks, or bottles are thus used; (3) quantities of materials called for are the minimum quantities that will serve the purpose; (4) measurement of quantity is by spoonfuls, except where accuracy is necessary or where some special end is in view or where materials are costly; (5) the questions used are such as tend to induce thought; (6) summaries of the experiments are called for, so pupils must review the experiment in hand and often previous experiments.

The forty-five experiments cover a wide range of topics, many of the later ones giving glimpses of qualitative analysis or of applied chemistry.

F. B. W.